

November 2014

Montana Residential Energy Code Handbook

2012 International Energy Conservation Code

As Amended



A Guide to Complying with Montana's Residential Energy Code

This document was compiled by the National Center for Appropriate Technology with input from the Montana Department of Labor and Industry and the Montana Department of Environmental Quality.

Montana Residential Energy Code Handbook

Prepared by the National Center for Appropriate Technology (NCAT)
3040 Continental Drive, Butte, Montana 59701

Author

Dale Horton, Architect
NCAT Sustainable Energy Program Manager

Reviewing Agencies

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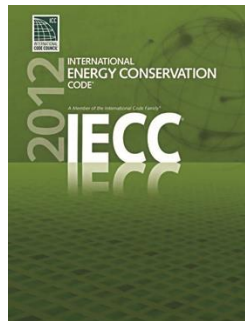
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Introduction and General Provisions

On November 7, 2014, Montana adopted the 2012 International Energy Efficiency Code (IECC) with a number of amendments. The previous state energy code was based on the 2009 IECC. The differences are significant. This document was produced to assist builders and designers in complying with Montana’s new energy code and to assist in the construction of homes that are more energy-efficient, healthier for the occupants, and more durable. This document is a complement to the Montana *Residential Buildings Energy Code Summary*, published by the Montana Department of Environmental Quality. This document *emphasizes the changes* to the code. A comprehensive energy code checklist is included at the end of the document. Neither of these publications are a complete substitute for the full text of the 2012 IECC with amendments. This handbook also highlights the building science basis for many code provisions and suggests best practices for complying with the code.



Building Science

The building science principles developed by building energy professionals for such programs as ENERGY STAR for New Homes are making their way into the model energy codes. This can be seen in the changes included in the 2012 IECC. An approach to building design and construction called “house-as-a-system” emphasizes the interaction of components and systems in understanding how buildings perform. This handbook goes beyond the simple code requirements to explain how to both comply with the code and construct better buildings.

Handbook Organization

This document's organization generally follows the order of the 2012 IECC itself. This is done to allow easy reference between the code text and this document. The language of the code itself can be a challenge to decipher but with this handbook as an introduction, the code will be easier to understand. The code is broken down into chapters, sections, and individual code provisions. Each provision paragraph is given a reference number and title. An example is "R401.1 Scope." The "R" refers to the residential, as opposed to the commercial, chapters of the code. This designation also refers to chapter four within the residential section of the code and indicates that information about the code "Scope" can be found in paragraph 401.1. In this handbook, the relevant code reference will be provided in the following format:

Typical 2012 IECC Reference Notation

R401.1

Energy Code Development

The International Codes Council (ICC) develops and maintains a family of building codes. Montana adopts many of these codes, including the International Residential Code (IRC) and the International Energy Conservation Code (IECC). The 2012 IECC was developed by committees during 2009 and 2010 and adopted at an annual ICC Codes Conference in 2010. During the code development process, industry stakeholders, such as the National Association of Home Builders, manufacturers, and energy efficiency advocates had opportunities to suggest changes to the code and to lobby for their particular views. The vote of the code officials attending the national conference established the 2012 IECC that is the basis of our state energy code.

The family of building codes are developed by the ICC to work together. There are many energy-related aspects of residential construction that are contained in the IRC and the International Mechanical Code (IMC). Montana adopts chapters 1 through 10, 15, and 44 of the IRC, along with the IECC and IMC with amendments. The following table points out that important energy-related

topics such as foam insulation properties, vapor retarders, crawlspace ventilation, and continuous whole-house ventilation are found in the IRC or the mechanical code.

How the Codes Overlap for Energy-Related Topics

Topic	IECC	IRC	IMC
HVAC Sizing	■		
Insulation Values	■		
Window/Skylight U-Factors	■		
House Tightening	■		
Duct Sealing and Tightening	■		■
Lighting Efficiency	■		
Foam Thermal Properties		■	
Vapor Retarders		■	
Crawlspace Ventilation		■	
Mechanical Ventilation		■	■

Montana Energy Code Is Applicable Statewide

The Montana state energy code is applicable to all residential buildings constructed in Montana with the exception of garages and storage buildings. The energy code is enforced on residential buildings of less than five units located outside local code enforcement jurisdictions through the “dwelling self-certification program.” Montana law requires, as an element of the self-certification program, that the builder provide a signed document to the building owner stating that the house complies with the state energy code.

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Energy Code Cost-Effectiveness

Cost-effectiveness is an important consideration in the code-development process. As one would expect, energy codes have become more efficient since their introduction. The changes to the 2012 IECC are expected to result in a 15% improvement in energy efficiency over the previous Montana energy code. A study by the U.S. Department of Energy found that, on average, the 2012 IECC will result in a seven-year simple payback for a new Montana home. Another analysis by the Montana Department of Environmental Quality estimated the average simple payback at 13 years across all utilities, fuel types, and house designs.

Major Changes to the Energy Code

Following is a list of the most significant changes to the Montana residential energy code:

- More efficient windows (from U-0.33 to U-0.32)
- More efficient skylights (from U-0.60 to U-0.55)
- More efficient crawlspace walls (from R-10/19 to R-15/19)
- Mandatory whole-house pressure test (one-year transition)
- Mandatory thermal envelope tightness checklist
- More stringent duct leakage test
- Mandatory whole-house mechanical ventilation
- Mandatory 75% high-efficacy lamps
- RESCheck will now be "better than code" (it had been "easier than code")

Major Amendments to the 2012 IECC

- Wall insulation requirement is unchanged at R-21 in the cavity or R-13 in cavity with R-5 continuous sheathing. (2012 IECC without amendment requires R-20 cavity with R5 continuous sheathing.)
- Maximum House Air Tightness is unchanged at 4 ACH50. (2012 IECC

without amendment requires 3 ACH50.)

- Building cavities may be used as return ducts. (2012 IECC without amendment does not allow use of building cavities for return ducts.)
- DHW distribution pipe requirements reflect minimal changes. (2012 IECC without amendment included insulation in a greater number of circumstances.)

What Buildings Must Comply?

R101.4

This code applies to residential buildings and the building sites, along with related equipment and systems. Residential buildings, according to the 2012 IECC, include detached one- and two-family dwellings, multiple single-family dwellings, and townhouses. Group R-2, R-3, and R-4 buildings less than four stories in height fall under the residential provisions of the energy code.

The energy code applies to additions, alterations, renovations, and repairs, as well as new construction. However, the energy code is not retroactive.

Unaltered portions of the original building do not need to comply. A good rule of thumb is that if it is new then it has to meet the energy code. However, there are several exceptions. Storm windows installed over existing windows do not have to meet the energy code, nor do glass-only replacements.

The residential energy code also applies when there is a change of occupancy that results in increased energy demand and when unconditioned space becomes conditioned.

Montana Residential Energy Code Application

- New construction
- Additions, alterations, and renovations
- When a space becomes conditioned
- Change of occupancy with greater energy demand
- Residential portion of mixed occupancy (<4 stories)

Construction Document Requirements

The energy code requires that the construction documents submitted for a building permit include “sufficient clarity to indicate the location, nature and extent of work proposed.” Items specifically required of the construction documents are listed below.

Construction Document Requirements

- Insulation materials and R-value
- Fenestration U-factors and SHGCs
- Mechanical system design criteria
- Mechanical and service water-heating system and equipment types, sizes, and efficiencies
- Equipment and system controls
- Fan motor HP and controls
- Duct sealing; duct and pipe insulation
- Lighting fixture schedule; wattage and control narrative
- Air-sealing details




Window, Door, and Skylight Ratings

R303.1.3

In both the R-value and U-factor tables, windows and doors (fenestration) and skylight values are given in terms of U-factor. The lower the U-factor, the better a product is at reducing heat loss. U-factor, when used for windows and skylights, takes into account more than conductivity. It also includes window air leakage. If a window, door, or skylight has no National Fenestration Rating Council (NFRC) label then the code official is to assume the values given in a default table in Section R303. The

default values of this table do not meet the prescriptive requirements for fenestration or skylights. The maximum U-factor allowed for fenestration in the new code is 0.32. In addition to displaying the U-factor, the NFRC label includes several other characteristics. Solar Heat Gain Coefficient (SHGC) can be useful in understanding how much of the sun's heat passes through the glazing. The higher the SHGC value between 0 and 1, the more solar heat will be admitted by the glazing. There is no requirement for Solar Heat Gain Coefficient in the Montana climate zone.

	World's Best Window Co. Millennium 2000+ Vinyl-Clad Wood Frame Double Glazing • Argon Fill • Low E Product Type: Vertical Slider	
	ENERGY PERFORMANCE RATINGS	
U-Factor (U.S./I-P) A 0.32	Solar Heat Gain Coefficient B 0.32	
ADDITIONAL PERFORMANCE RATINGS		
Visible Transmittance C 0.51	Air Leakage (U.S./I-P) D 0.2	
Condensation Resistance E 51	—	
<small>Manufacturer stipulates that these ratings conform to applicable NFRC procedures for determining whole product performance. NFRC ratings are determined for a fixed set of environmental conditions and a specific product size. NFRC does not recommend any product and does not warrant the suitability of any product for any specific use. Consult manufacturer's literature for other product performance information. www.nfrc.org</small>		

Insulation Identification

R303.1

An R-value identification mark must be applied by the manufacturer to each piece of insulation 12 inches or greater in width. Insulation must be installed so that the manufacturer's R-value mark is readily visible. Blown or sprayed roof/ceiling insulation thickness must be written in inches on markers at least one every 300 square feet through the attic space in letters one inch high facing the attic access opening. Other insulation marking details can be found in the code.

Compliance Path Options

New residential buildings must comply with “mandatory” provisions of the code and, for the thermal envelope, either the provisions associated with the “prescriptive” or “performance” approaches. The prescriptive path includes three alternatives. The most familiar but least flexible prescriptive method is the **R-value Computation Alternative**, which is based on a table of R-values (for opaque components). The **U-factor Alternative** method is based on a table of U-factors but must consider the entire component assembly. The **Total UA Alternative** method is also based on that table of U-factors but allows tradeoffs between the different building envelope components. The Total UA Alternative is the most flexible of the prescriptive methods and RESCheck software is based on this approach. The performance path is the most flexible of all options but is also the most complex in that it requires very detailed inputs and analysis performed with an approved building performance simulation software such as REM/Rate™ or REM/Design™.

Mandatory Provisions



Envelope Provisions

Prescriptive Path Options <ul style="list-style-type: none">▪ R-Value▪ U-Factor (Total Assembly)▪ Total UA (RESCheck)	OR	Performance Path
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Thermal Envelope

Prescriptive R-Value Compliance

R-Value Prescriptive Requirements		R402.1
Component	Insulation, Window, Door, and Skylight Requirements	Remarks
Windows & Doors	U-0.32	
Skylights	U-0.55	
Ceiling	R-49	R-38 complies if uncompressed insulation extends over top of exterior wall top plate
Wood Frame Wall	R-21 or R-13+5	First value is cavity insulation, second value (if present) is continuous sheathing
Mass Wall	R-15/R-20	Second value applies when more than half of R-value is on interior of mass wall
Floor	R-30	Insulation that fills cavity (R-19 minimum) also complies
Basement Wall	R-15/R-19	First value is continuous, second value is cavity
Slab	R-10, 4'	Insulation must extend downward continuously from top of slab for 4 feet vertically or horizontally
Crawlspace Wall	R-15/R-19	First value is continous inside or outside, second value is cavity insulation on inside

Thermal Envelope

The R-values in the table on page 10 refer only to the insulation and not to other components of the wall, ceiling, or floor assembly. Log, concrete block, and insulated concrete form walls must comply with the “mass” wall requirements of R-15 unless more than half of the insulation is on the interior when R-20 is required.

U-Factor (Total Assembly) Compliance Alternative R402.1.3

When using the U-factor table, the characteristics of the entire assembly are considered. For example, in a wall, the insulating characteristics of the air films, sheathing, and interior finish are included in the calculation. The area weighted U-factors of the wall and framing members and headers must be included in the calculation.

Total UA (RESCheck) Compliance Alternative

The third prescriptive method for envelope compliance is called the Total UA Alternative. This method allows tradeoffs between the various envelope components. For example, the walls of a particular building may not meet the R-value table minimum requirement, but if the windows are better than code, the envelope as a whole may comply. In this method, each area of the envelope with a different thermal characteristic is multiplied by its associated area in square feet. The sum of all UA products (U-factor x area) for the proposed building is compared to a building based on the code maximum U-factors. If the UA total of the proposed building is less than the UA of the code-based building, then the building complies. RESCheck software uses the Total UA Alternative method to demonstrate building envelope

U-Factor Table	
Component	Insulation, Window, Door, and Skylight Requirements
Windows & Doors	U-0.32
Skylights	U-0.55
Ceiling	0.026
Wood Frame Wall	0.054
Mass Wall	0.06; 0.57 if >50% insul. on interior
Floor	0.033
Basement Wall	0.05
Crawlspace Wall	0.055

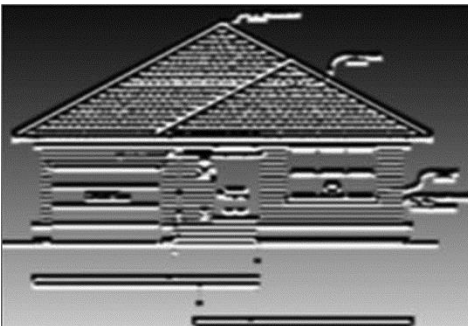
compliance. RESCheck software may be obtained at no cost at www.energycodes.gov/rescheck.

Performance Compliance Alternative

R405

The performance path is seldom used despite offering the greatest flexibility in demonstrating energy code thermal envelope compliance. This alternative uses sophisticated energy-performance software, such as REM/Design™ or Energy Gauge™, to determine if the proposed design has an annual energy cost less than or equal to a reference design, it's so-called geometric twin. The mandatory provisions of the energy code are required when the performance compliance approach is used. Some of the building energy characteristics that can be considered using the performance alternative that are not considered by the prescriptive compliance alternatives include:

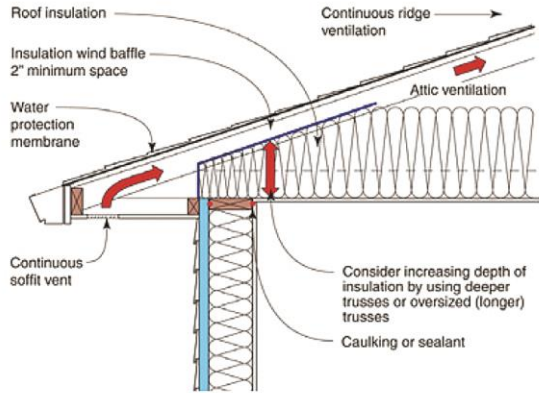
- Exterior Shading
- Solar Heat Gain
- Innovative Framing Techniques
- Cool Roofing Systems
- Thermal Mass
- Solar Energy Systems
- Low Infiltration
- Insulation Identification



Eave Baffles

R402.2.3

For air-permeable insulation in vented attics a baffle must be installed adjacent to the soffit and eave vents to maintain an opening equal to or greater than the size of the vent. The baffle must extend over the top of the attic insulation.



Source: USDOE Building Technologies Program, Introduction to Building Systems Performance: Houses That Work II

Installation Per Manufacturer's Instructions

R403.2

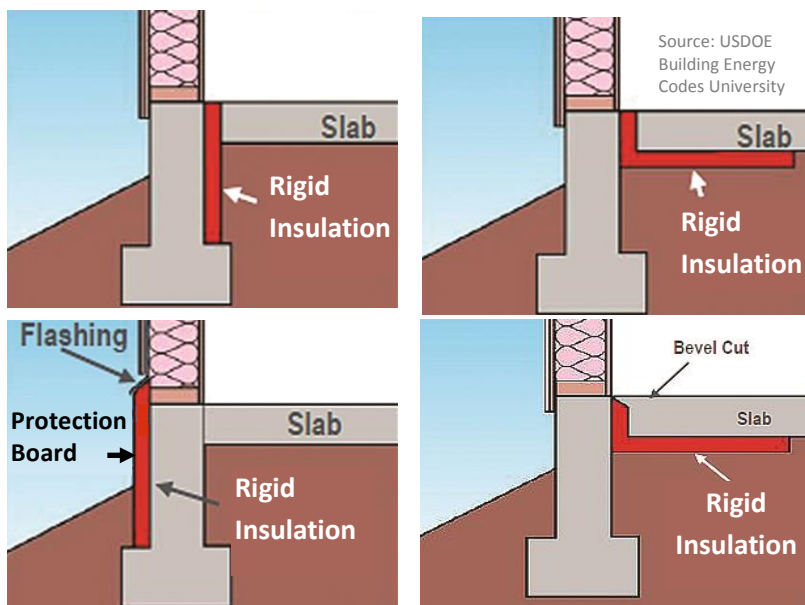
All materials, systems, and equipment must be installed according to the manufacturer's installation instructions. In the photos below, the fiberglass batt insulation does not meet code because the gaps and compressions do not meet the manufacturer's specifications. Manufacturer's installation specifications are an enforceable extension of the code.



Slab-on-grade Floors

R402.2.10

Slab-on-grade floors, less than 12 inches below grade, must be insulated with R-10 continuous insulation that extends downward from the top of the slab on the inside or outside of the foundation wall. The insulation must extend for a distance of four feet vertical or horizontal. Insulation extending away from the building must be protected by paving or at least 10 inches of soil.



Crawlspace

R402.2.10

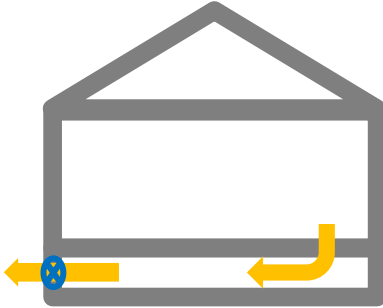
The International Residential Code (IRC) allows either vented or unvented crawlspaces. If the crawlspace is vented, the floor must be insulated. If the crawlspace is unvented, then the crawlspace walls must be insulated. The IRC (R408.3) goes on to allow two design options for an unvented crawlspace, either mechanically vented or minimally conditioned (a so-called mini-basement). In either case, the required air flow is specified by the code and an air pathway to the house common area is required. All unvented crawlspaces must have a

continuous Class I vapor retarder at exposed earth. This requirement is critical since radon, moisture, and other soil gases can find their way into the home without a sealed vapor retarder on the floor of the crawlspace. The vapor retarder must have a six-inch overlap that is sealed or taped and must extend six inches up the stem wall where it is attached and sealed

Unvented Crawlspace – Two Design Options

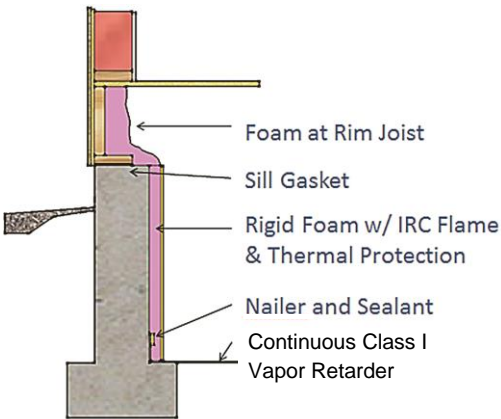
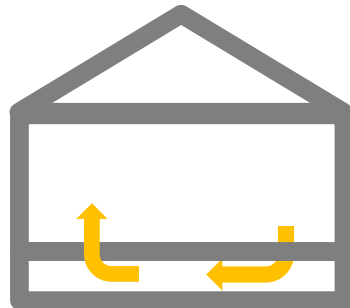
Continuous Exhaust to Exterior

- 1 CFM/50 SF Crawlspace Area
- Air Pathway from Common Area

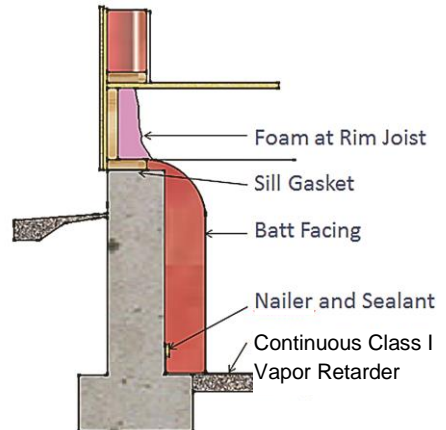


Conditioned Air Supply

- 1 CFM/50 SF Crawlspace Area
- Air Pathway to Common Area



Interior Crawlspace Rigid Board Insulation



Interior Crawlspace Batt Insulation

Air Leakage

Blower Door Test
 ≤ 4 ACH50



Air Barrier &
 Insulation
 Checklist

In the previous edition of the energy code, a home could comply with air sealing with either a blower door test (maximum leakage four air changes at 50 pascals) or by complying with the Air Barrier and Insulation Installation table. This table is often referred to as the “Visual Checklist.” In the new code, a home must pass a blower door test as well as complying with the visual checklist. ***The mandatory blower door test will take effect on November 7, 2015.***

The original 2012 IECC language regarding who may perform the blower door test has been amended slightly for Montana. The code official, according to the new language, may require that the testing or the visual checklist be “conducted by an approved party.”

“Where required by the code official, testing shall be conducted by an *approved party*.”

A copy of the Air Barrier and Insulation Installation table is included with the energy code checklist at the end of this handbook. More information about blower door testing is included later in this section. The blower door test procedure includes closing all exterior doors and windows and disabling all combustion appliances and exhaust fans. The air flow measurement at 50 Pa through the large fan installed in an exterior doorway is then used to calculate the air change rate for the house. While the blower door testing process is not complex, it takes care to properly set up the house and configure the digital manometer. Following are selected details that illustrate provisions of the Air Barrier and Insulation Installation checklist.

Source: The photos on pages 17-19 are courtesy of the Northwest ENERGY STAR Homes Program and its contractor Advanced Energy.

Top plate and bottom plate of exterior walls sealed.



Air barrier in any dropped ceiling aligned with insulation and any gaps in air barrier sealed.



Floor insulation in permanent contact with underside of subfloor decking.



Recessed light fixtures installed in thermal envelope air-tight, IC-rated, and sealed to drywall.



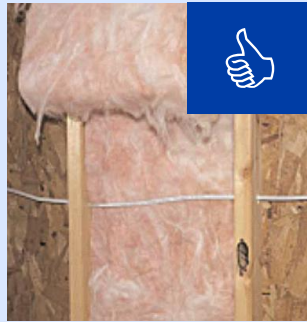
Utility penetrations opening to exterior or unconditioned space must be sealed. No fibrous insulation is used to fill holes.



Utility penetrations opening to exterior or unconditioned space must be sealed.



Batt insulation cut neatly around wiring and plumbing in exterior walls.



Exterior walls adjacent to showers and tubs insulated with air barrier separating them from the shower and tubs.

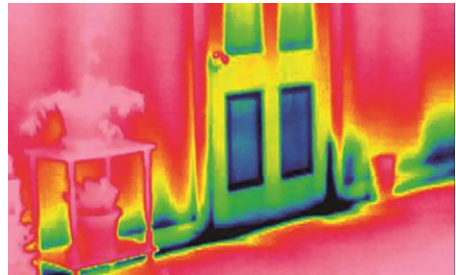


Thermal Envelope Building Science Background

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.

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. This infrared scan 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.



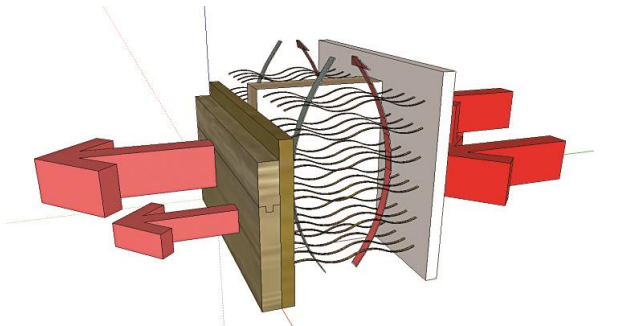
Convection is heat transfer by a moving fluid or gas such as air or water. This heat movement is caused by the density difference between warmer and cooler parts of fluid. Warm air rises to the top of a building where it either escapes to the attic, and eventually outside, or is cooled and falls. It 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 building and low pressure at the bottom of the building.



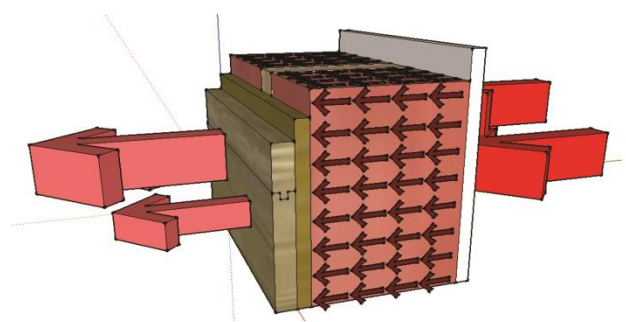
Heat transfer by **radiation** occurs when heat is transferred through space or air from one object to another. An example is the sun radiating heat through space to the earth. Heat transfer by radiation requires a temperature difference between objects, a gap, and an unimpeded “line of sight.” We can 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.

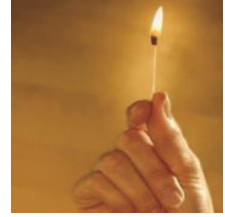


If the wall cavity is filled with a non-air permeable insulation such as high-density foam, heat loss by convection and radiation no longer occurs. All heat loss through such a wall is by conduction.



R-Values and U-Factors

Understanding a few basic energy terms and concepts will help in complying 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**, or 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 match.

Building Envelope Control Functions

The paramount 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 yet provide a long, useful service life, if allowed to dry. The following pages discuss the functions of a well-designed wall. These general principles also apply to roof/attic assemblies.

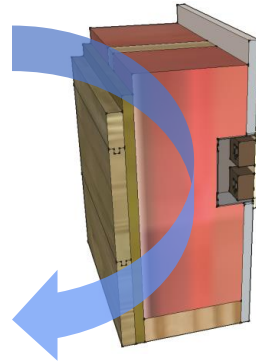
Function

Minimize Wind Washing

Wind washing reduces the effectiveness of air-permeable insulation such as fiberglass batts.

Solution

Install Continuous Exterior Air Barrier



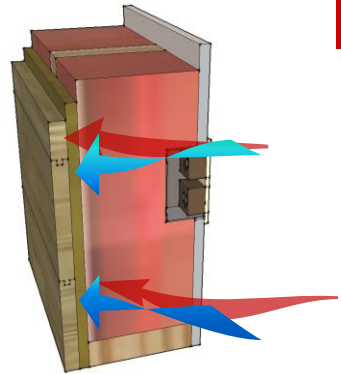
Function

Minimize Air (and 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 are cold enough, then water vapor will condense, resulting in mold or other damage to the structure.

Solution

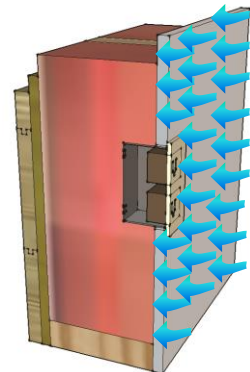
Install Continuous Interior Air Barrier



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



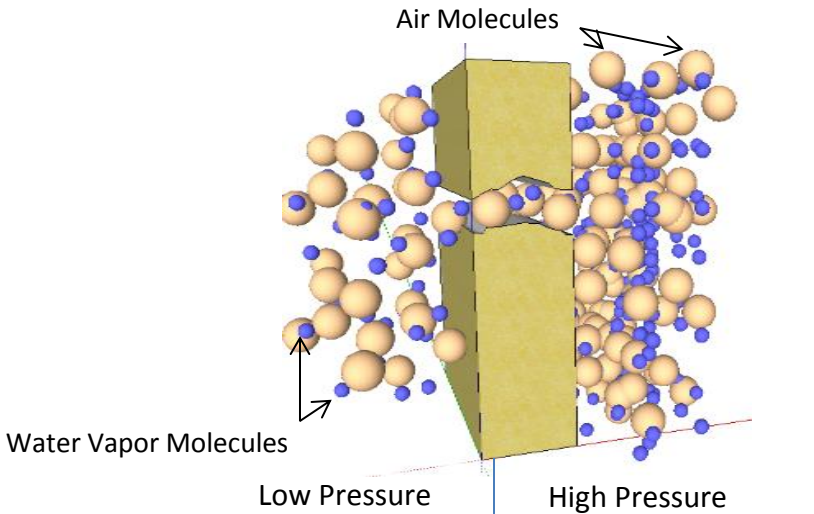
control vapor diffusion into the building envelope, the vapor retarder in Montana's climate must be located on the warm side of the wall. Water vapor diffusion plays a role on both sides of the moisture balance: as a wetting source and also as a drying pathway.

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.

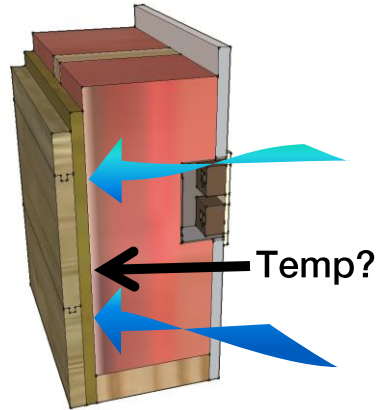


Function

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.



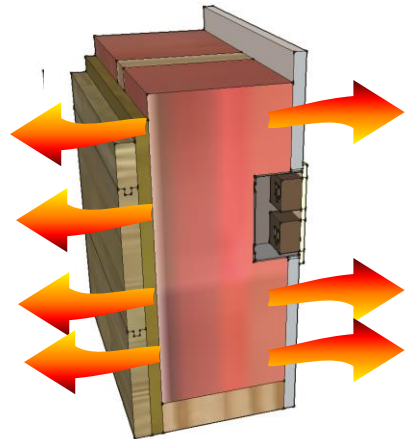
Solution

Insulate Condensation Surface

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

Air Barriers and Vapor Retarders

An **air barrier** is a material or assembly of materials that provide a barrier to air leakage through and into the building envelope. An air barrier may be a single material or a combination of materials. A **vapor retarder** limits the amount of moisture that passes through a material or assembly. The term “vapor barrier” is no longer used in the codes. Instead, the IRC defines classes of vapor retarders. A Class I vapor retarder is essentially impermeable. Sheet polyethylene is one example. Typically, latex paint is considered a class III vapor retarder.

The IRC (R702.7) requires that a Class I or II vapor retarder be installed at the warm side of exterior walls. An exception to this requirement is at basement walls and any portion of other walls below grade.

Class	Definition	Examples	Remark
I	0.1 perm or less	Sheet polyethylene, sheet metal, non-perforated aluminum foil	Impermeable (vapor barrier)
II	Greater than 0.1 perm but less than 1.0 perm	Kraft-faced fiberglass batts or low-perm paint	Semi-impermeable
III	Greater than 1.0 perm but less than 10 perm	Latex or enamel paint	Semi-permeable



House Tightness Testing

House tightness is measured by a **blower door test**. In a blower door test, an exterior door is fitted with a nylon skirt with an opening for a large fan. For new construction, it is most common to perform a depressurization blower door test. The blower door exhausts air from the house until the home has a negative pressure of 50 Pa with reference to the outside. The amount of air that flows out of a house is equal to the amount of air that leaks into the house through the envelope and exterior ducts. A digital manometer is used to measure the pressure difference and the air flow out of the fan.



Depressurization Blower Door Test

Pressurization blower door tests are performed most often in existing homes when there is a possibility that asbestos or other unwanted dust or particles may be present in the building cavities. A pressurization blower door test usually takes longer to perform since the exhaust backdraft dampers must be sealed before testing occurs.



Pressurization Blower Door Test

The mandatory blower door test will take effect on November 7, 2015.

The blower door fan includes the fan housing and several rings to adjust the size of the fan opening. The nylon skirt is held in the doorway by a metal frame. The motor speed controller allows the technician to control the speed of the fan. The knob on the fan controller is turned until the manometer displays the pressure in the house as 50 Pa with reference to outside. The air flow at this pressure is equal to envelope leakage.



Blower Door

The blower door test procedure includes closing all exterior doors and windows and disabling all combustion appliances and exhaust fans. The air-flow measurement at 50 Pa is then used to calculate the air change rate for the house. While the blower door testing process is not complex, it takes care to properly set up the house and configure the digital manometer.



Digital Manometer

Blower Door Math

To calculate air changes per hour at 50 Pascals

$$\text{ACH}_{50} = \frac{\text{CFM}_{50} \times 60}{\text{House Volume}}$$

House volume is cubic feet enclosed by the thermal envelope including exterior walls.

Systems

Duct Insulation and Sealing

R403.2

Supply ducts in attics must be insulated to at least R-8 and all other ducts must be insulated to R-6. Duct insulation is not required if the ducts are located inside the building thermal envelope. Ducts, air handlers, and filter boxes must be sealed. The energy code requires that all ducts be sealed with mastic or UL-listed tapes. Currently, the author is unaware of any tapes that have the required UL listing. Most duct mastic manufacturers specify that mastic should be 1/16th inch thick, about the thickness of a nickel.

Duct leakage, even if the ducts are located entirely within the conditioned space, can cause comfort issues and potentially lead to negative pressures in the combustion appliance zone which, in turn, can cause backdrafting.

Duct Tightness Testing

R403.2.2

The new energy code requires tighter ducts. Ducts do not have to be tested if the ducts and air handler are entirely within building thermal envelope. The ducts may be tested either at the postconstruction or rough-in stages. If tested at Postconstruction, either the total duct leakage test or the duct leakage to the outside test may be used. The duct tightness limit is the same for both tests, 4 cfm per SF when tested at 25 Pa.

Ducts do not have to be tested if the ducts and air handler are entirely within the building thermal envelope.

Postconstruction Duct Leakage Test
Total Leakage or Leakage to the Outside
 ≤ 4 cfm/100 SF (at 25 PA)

Former leakage to outside limit was 8 cfm/100 SF
Former total leakage limit was 12 cfm/100 SF

Rough-in Test Duct Leakage Test

Total Leakage

≤ 4 cfm/100 SF (at 25 PA)

Former total leakage limit was 6 cfm/100 SF



Building Cavities as Ducts

R403.2.3

The Montana energy code allows building cavities to be used as return ducts but not for supply ducts. This was a Montana amendment, as the 2012 IECC prohibits use of building cavities for either supply or return.



Source: USDOE Building Energy Codes University

Hot Water Pipe Insulation

R403.4.2

R-3 insulation is required on domestic hot water piping for a number of conditions. Those conditions include piping over $\frac{3}{4}$ " in diameter, serving more than one dwelling, outside the conditioned space, to a distribution manifold, located under a floor slab, buried, and supply and return piping in recirculation systems. Montana amendments eliminated some additional insulation requirements that were included in the 2012 IECC.

Whole-House Mechanical Ventilation

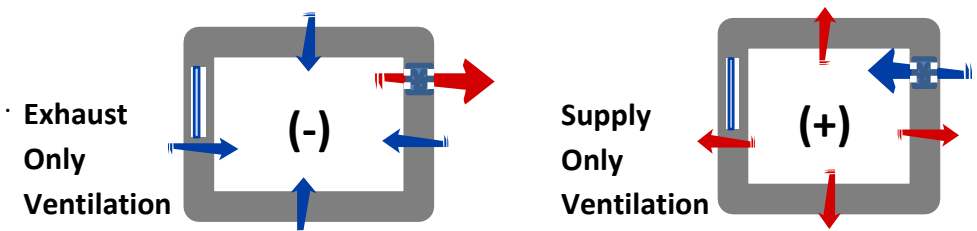
R403.5 IRC M1507.3.3

The 2012 IECC requires whole-house mechanical ventilation systems that meet the provisions of the IRC. The IRC (R303.4) in turn requires a whole-house mechanical ventilation system per Chapter 15 of the IRC or the International Mechanical Code. Montana allows either Chapter 15 of the IRC or the International Mechanical Code to be used in complying with the code. The requirements of both are similar but IRC Chapter 15 is much more user-friendly. The whole-house mechanical ventilation requirement is one of the most significant changes in the new energy code.

Since the fans associated with a whole-house mechanical ventilation system will be operating continuously in most cases, the code calls for the use of efficient fans. The table below specifies the efficiency of the fans that provide the required whole-house mechanical ventilation. Efficiency is given in cfm/watt.

TABLE R403.5.1 MECHANICAL VENTILATION SYSTEM FAN EFFICACY			
FAN LOCATION	AIR FLOW RATE MINIMUM	MINIMUM EFFICACY	AIR FLOW RATE MAXIMUM
	(CFM)	(CFM/WATT)	(CFM)
Range hoods	Any	2.8 cfm/watt	Any
In-line fan	Any	2.8 cfm/watt	Any
Bathroom, utility room	10	1.4 cfm/watt	< 90
Bathroom, utility room	90	2.8 cfm/watt	Any

An IRC Chapter 15 table, shown on page 32, specifies the minimum required continuous ventilation air flow based on the floor area and number of bedrooms of the house. The code states that the ventilation may be either exhaust or supply, but a supply-only ventilation system is inappropriate for the Montana climate. We will discuss this further in terms of building science.



**TABLE M1507.3.3(1)
CONTINUOUS WHOLE-HOUSE MECHANICAL VENTILATION SYSTEM
AIRFLOW RATE REQUIREMENTS**

DWELLING UNIT FLOOR AREA (square feet)	NUMBER OF BEDROOMS				
	0-1	2-3	4-5	6-7	> 7
	Airflow in CFM				
< 1,500	30	45	60	75	90
1,501 - 3,000	45	60	75	90	105
3,001 - 4,500	60	75	90	105	120
4,501 - 6,000	75	90	105	120	135
6,001 - 7,500	90	105	120	135	150
> 7,500	105	120	135	150	165



For example, a house of 2,500 Ft² conditioned floor area that has three bedrooms would require 60 cfm of continuous ventilation as shown below.

DWELLING UNIT FLOOR AREA (square feet)	NUMBER OF BEDROOMS				
	0-1	2-3	4-5	6-7	> 7
	Airflow in CFM				
< 1,500	30	45	60	75	90
1,501 - 3,000	45	60	75	90	105
3,001 - 4,500	60	75	90	105	120

If the home uses intermittent ventilation instead of continuous ventilation, then the capacity of the ventilation system must be greater. For example, if the whole-house mechanical ventilation system will operate only 50% of the time, the capacity of the system must be increased by a factor of 2 as specified by the table shown.

TABLE M1507.3.3(2)
Intermittent Whole-House Mechanical Ventilation Rate Factors

Run-Time Percent in Each 4-Hour Segment	25%	33%	50%	66%	75%	100%
Factor	4	3	2	1.5	1.3	1.0

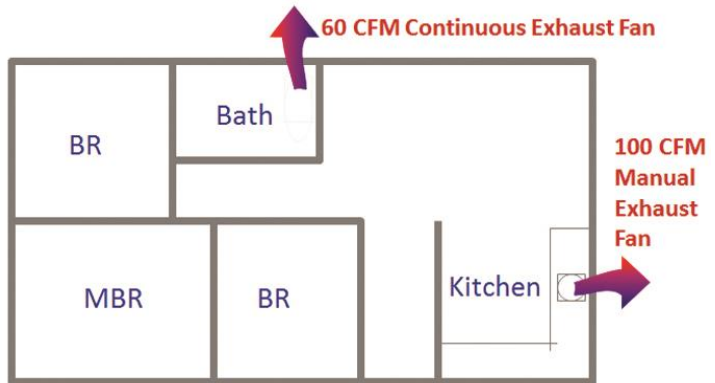
In addition to the whole-house ventilation system, the code also requires minimum local exhaust capability in kitchens and bathrooms. Kitchens must have either a 100-cfm, manually controlled exhaust or a 25-cfm continuous exhaust. Bathrooms must have either a 50-cfm manually controlled exhaust or a 20-cfm continuous exhaust. If continuous exhaust is used to comply with the local exhaust requirement, it may also be counted toward whole-house mechanical ventilation.

Table M1507.4
Minimum Required Local Exhaust Rates for One- and Two-Family Dwellings

Area to Be Exhausted	Exhaust Rates
Kitchens	100 cfm intermittent or 25 cfm continuous
Bathrooms-Toilet Rooms	Mechanical exhaust capacity of 50 cfm intermittent or 20 cfm continuous

Below is a very simple example. A single-story, three-bedroom house is 2,000 ft² in floor area. Per the table on page 32, this house requires 60 cfm of continuous ventilation. This house complies with code with a continuous 60-cfm exhaust in the only bathroom and a 100-cfm manually controlled exhaust fan in the kitchen.

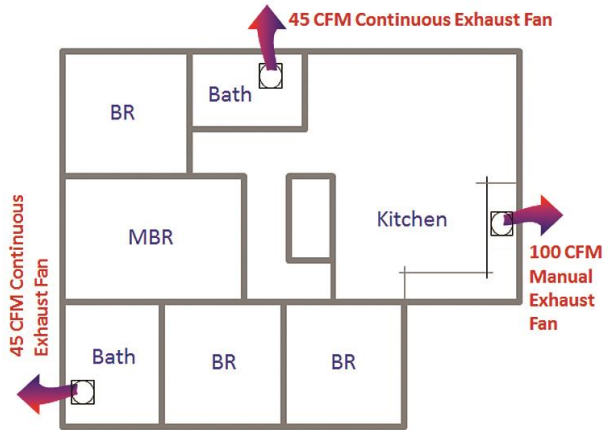
Mechanical Ventilation Example 1



3BR, 2000 SF House = 60 CFM Needed

In another example, shown on page 35, a four-bedroom 3,600 ft², one-story home would require 90 cfm of ventilation air-flow according to Chapter 15 of the IRC. One way to accomplish this is to have a continuous 45-cfm exhaust fan in each of the two bathrooms and a 100-cfm manually controlled exhaust fan in the kitchen.

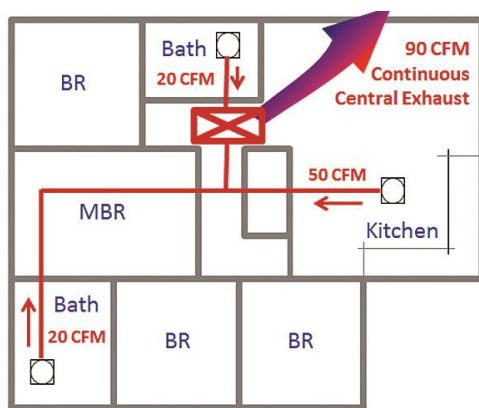
Mechanical Ventilation Example 2



4BR, 3600 SF House = 90 CFM Needed

Below is another approach for the same four-bedroom, 3,600 ft², one-story home. A central exhaust system would continuously exhaust 20 cfm from each of the two bathrooms and 50 cfm from the kitchen. This satisfies both the continuous air flow requirement and the local exhaust requirement. The central exhaust system could provide heat recovery with a heat recovery ventilator.

Mechanical Ventilation Example 3

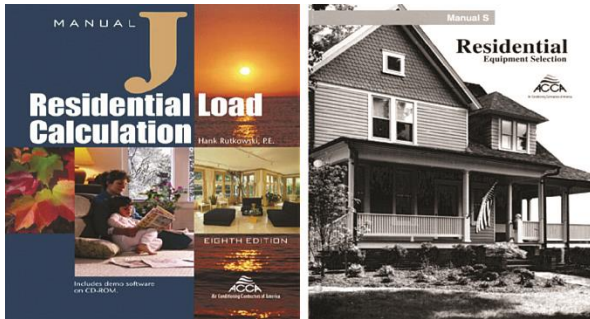


4BR, 3600 SF House = 90 CFM Needed

Equipment Sizing

R403.6

While not a code change, it is worth noting that heating and cooling equipment must be sized in accordance with ACCA Manual S and based on loads calculated according to ACCA Manual J. Oversizing equipment results in short cycling, which can reduce equipment life, reduce efficiency, reduce filter effectiveness, and results in poor dehumidification during the cooling season.



ACCA Manual J and Manual S

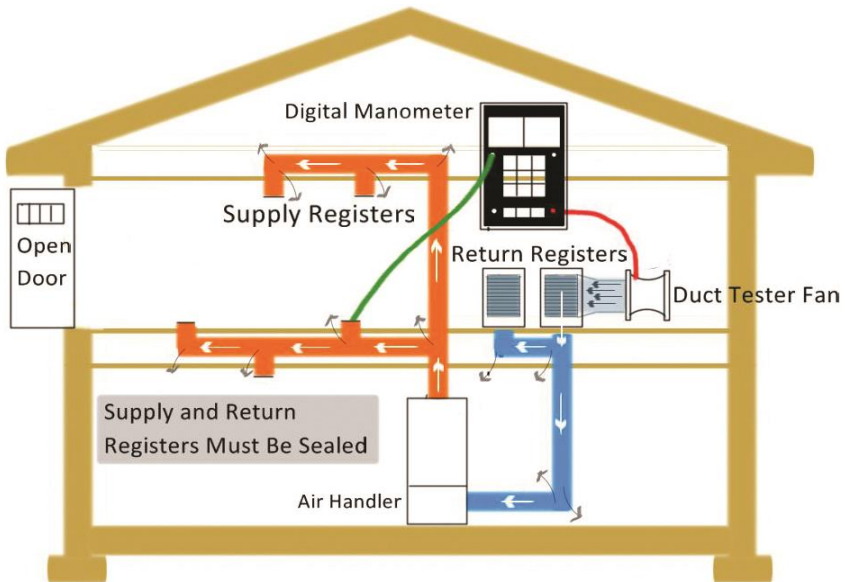


Heat Recovery Ventilator

Systems Building Science Background

Duct Tightness

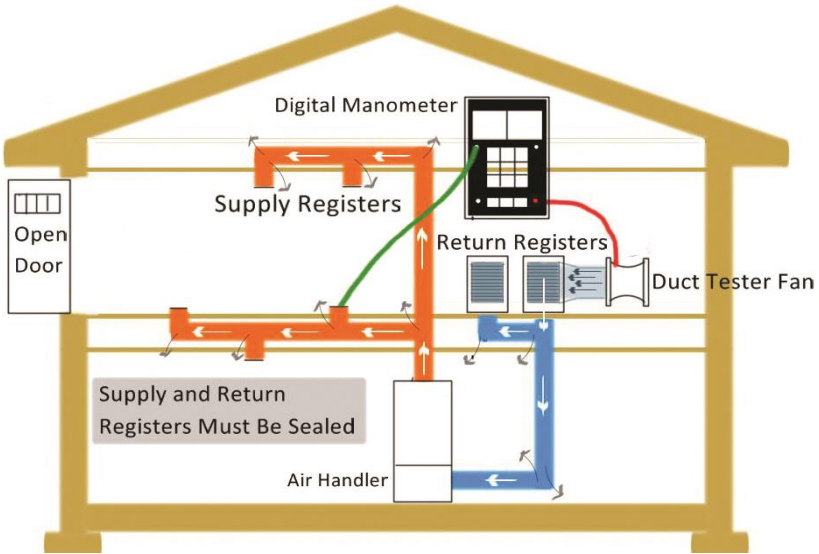
Two types of duct tightness testing are allowed by the Montana energy code. The **total duct leakage** test measures the duct leakage from the entire duct system regardless of whether it is located inside or outside the conditioned space. To conduct a total duct leakage test, all supply and return registers are sealed. The duct tightness tester fan is attached at the air handler cabinet or the return register nearest the air handler. The air flow required to bring the duct



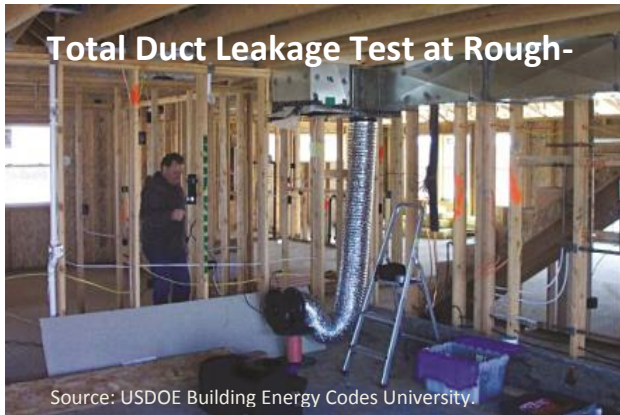
Total Duct Leakage Test

system to 25 Pascals is equal to the air leaking out of the duct system at that pressure. The total duct leakage test is simpler and takes less time to perform. The **duct leakage to the outside** test is more complex because the blower door fan must also be used to pressurize the house to 25 Pa with reference to outside. The duct tester fan is then used to bring the pressure in the duct system to zero with reference to the house. Since air requires an opening and a

pressure difference to flow, the duct leakage to the outside test eliminates air leakage within the house from the test results (since duct pressure is the same pressure as the house). Therefore, the only leakage measured with the duct tester fan will be outside of the conditioned space.



Duct Leakage to the Outside Test



It is not unusual to have a duct joint become disconnected accidentally. The cavity can be finished without anyone noticing the gap. A duct test will identify such problems. This is one reason to test duct tightness even if the ducts are all located within the conditioned space.

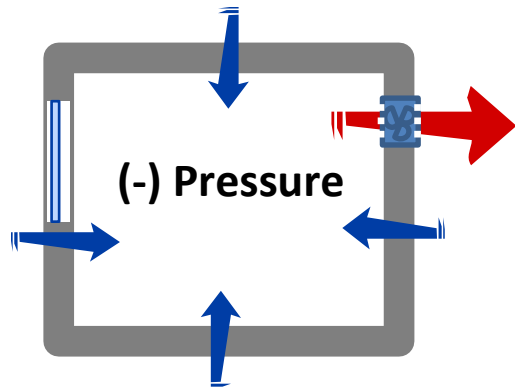


Disconnected Duct

Building Science and Mechanical Ventilation

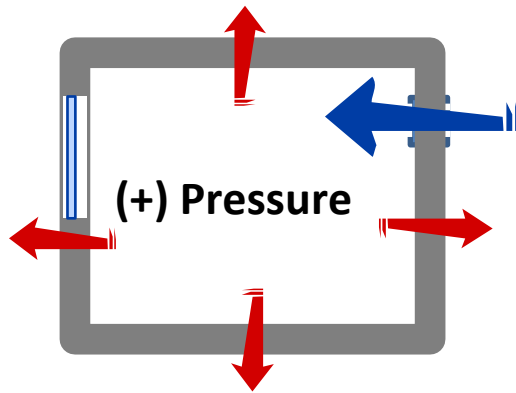
The four basic types of mechanical ventilation are diagramed below. **Exhaust-only systems** depressurize the house with exhaust fans without providing planned pathways for make-up air. **Supply-only systems** pressurize the house with supply fans without providing planned pathways for exhaust air. The make-up air for both the supply- and exhaust-only systems comes from the various air leaks in the building envelope. Since pressurizing the house will force warm, moist, interior air into the building cavities supply-only ventilation systems are not recommended for cool, dry climates like that of Montana.

Exhaust-Only Mechanical Ventilation

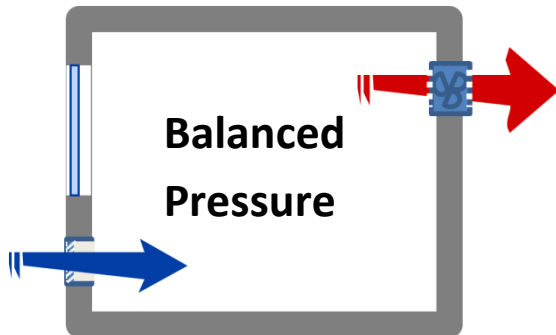


Supply-Only Mechanical Ventilation

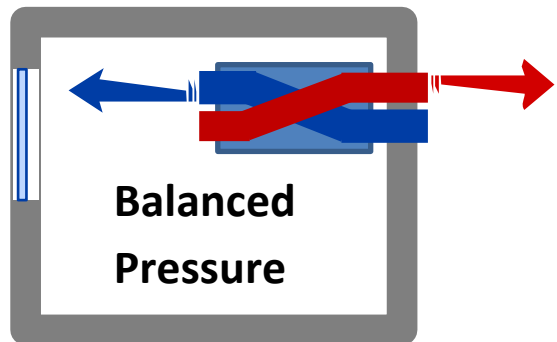
Not recommended for the Montana climate.



Balanced Mechanical Ventilation without Heat Recovery

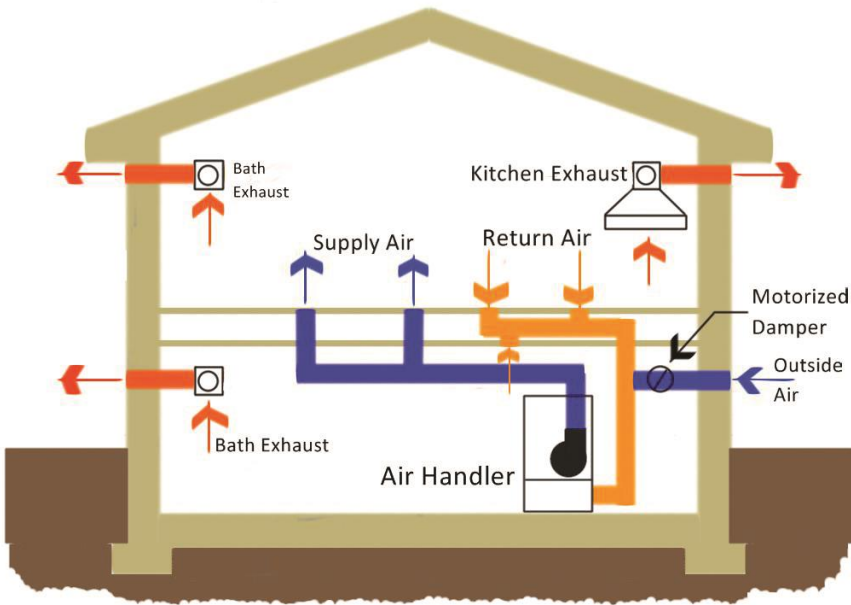


Balanced Mechanical Ventilation with Heat Recovery



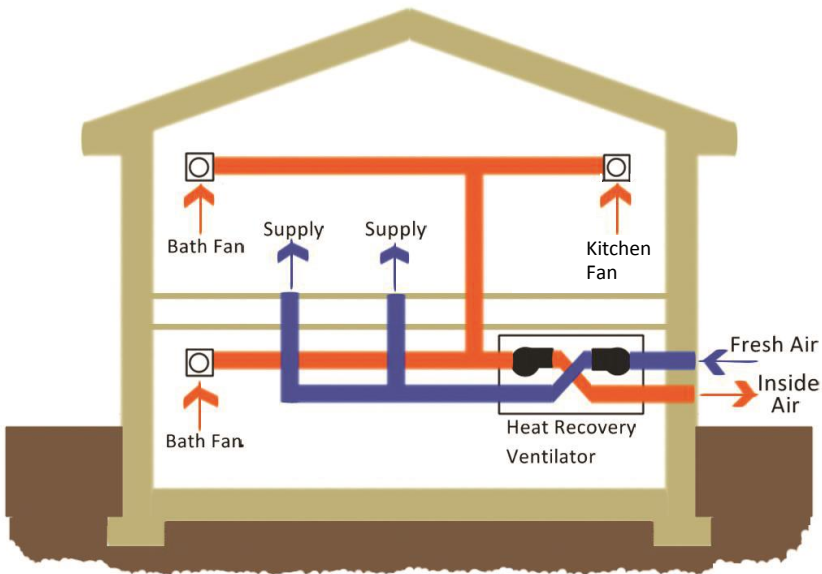
In **balanced ventilation**, there is a dedicated make-up air path designed into the system. Providing this dedicated make-up air pathway has several benefits. It minimizes problems of over-pressurizing and under-pressurizing spaces within the home. A balanced ventilation system is more likely to provide design air quantities. Make-up air is provided through planned pathways, which improves air quality. Balanced systems may also provide heat recovery. While balanced ventilation has many advantages, it is also more costly.

Below is a diagram of a balanced ventilation system without heat recovery. Air is exhausted from fans located in the kitchen and bathrooms. Fresh air is provided through a make-up air duct connected to the return side of the air handler. This make-up air duct is equipped with a motorized damper that is operationally integrated with the air handler and exhaust fans.



Balanced Central Exhaust without Heat Recovery

The diagram below shows a balanced central exhaust ventilation system with heat recovery. In this system, air is collected from spaces in the home that are most likely to produce moisture and is then exhausted at a central point. Fresh air is supplied by the central ventilation system to one or more spaces in the home. Balanced ventilation systems may include heat recovery. When an air handler is present, the fresh air supply from the heat recovery ventilator (HRV) can be connected to the return side of the air handler and the low-speed air handler fan is interconnected with the operation of the HRV. Typically, an HRV will transfer 60% to 90% of the heat in the stale air being exhausted from the home to the fresh air entering the home.



Balanced Central Exhaust with Heat Recovery

Lighting

The lighting provisions of the energy code have changed. The new code requires a minimum of 75% of the all lamps or 75% of permanently installed lighting fixtures to be high-efficiency. In other words, there are two ways to comply, either by lamp count or fixture count. In either case, exterior lamps and fixtures are counted. There is an exception for low-voltage lighting, which is not required to utilize high-efficiency lamps.

75% High-Efficacy by either:
1. Lamps Count; or
2. Fixture Count

High-Efficacy Lamps are:

- Compact fluorescent lamps (CFL)
- T-8 or small diameter linear fluorescent lamps
- Lamps that meet the minimum lumens/watt

High-Efficacy Lamp Values

- 60 lumens per watt if over 40 W
- 50 lumens per watt if between 40 and 15 W
- 40 lumens per watt if 15 W or less



Montana Builder's Energy Code Checklist (2012 IECC) p 1 of 4

Montana Builder's Energy Code Checklist (2012 IECC)					
* Indicates Montana Energy Code value that was amended from the 2012 IECC.					
Date		Builder			
House Address				City	
<input type="checkbox"/> New Construction		<input type="checkbox"/> Addition to Existing Building		<input type="checkbox"/> Existing Building Renovation	
<input checked="" type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> N/A	Component	Code Provision	Presc. Code Value	RESChk Tradeoff Value	2009 IECC Code Section
Pre-Inspection/Plan Review					
<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	Construction Documents	Construction drawings sufficiently demonstrates energy code compliance			R103.2
<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	HVAC Load Calculations	HVAC loads sized according to ACCA Manual J			R403.6
Foundation					
<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	Slab	Unheated slab edge insulation R-value	R-10		R402.1.1
<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>		Heated slab edge insulation R-value	R-15		R402.2.9
<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>		Depth/length from top of slab	4 ft		
<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	Basement Wall	Continuous exterior insulation	R-15		R402.1.1
<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	Exterior Insulation	Insulation depth (or to basement floor)	10 ft		R402.2.8
<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	Crawl Space	Continuous, Exterior	R-15 *		
Framing/Rough-in					
<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	Windows & Doors	Area weighted average (maximum value)	U-0.32*		R402.1.1
<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	Skylight	U-factor (maximum value)	U-0.55*		R402.1.1
<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	Mass Wall **	More than 50% of insulation on interior	R-20 *		R402.1.1
<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>		Less than 50% of insulation on interior	R-15		R402.1.1
<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	Duct Insulation	Supply ducts in unconditioned attic	R-8		R403.2.1
<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>		All other ducts outside thermal envelope	R-6		
<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	Ducts	Sealed with approved tapes, mastics, and gaskets			R403.2.2
<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>		Building cavities not used for supply ducts			R403.2.3

** - Mass walls include log, solid timber, concrete block, and insulated concrete forms.

Montana Builder's Energy Code Checklist (2012 IECC) p 2 of 4

House Address			City		
<input type="checkbox"/> <input type="checkbox"/> N/A	Component	Code Provision	Presc. Code Value	RESChk Tradeoff Value	2009 IECC Code Section
Insulation					
<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	Crawl Space	Cavity Insulation	R-19		R402.1.1 R402.2.10
<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>		Continuous, Interior	R-15		
<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>		Continuous Class 1 vapor retarder, joints overlapped 6" and sealed, extending 6" up the stem wall			
<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	Basement Wall Interior Insulation	Continuous Insulation	R-15		R402.1.1
<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>		Framed wall	R-19		R402.1.1
<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	Floor Insulation	Must be in contact with floor sheathing	R-30		R402.1.1
<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	Exterior Walls	Framed wall	R-21		R402.1.1
<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>		Framed wall + continuous	R-13+R-5		R402.1.1
<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	Air Sealing	Tested by blower door (ACH50)	≤4		R402.4.2.1
<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>		Air Barrier and Insulation Installation			R402.4.1.1
<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	Ceiling Insulation	Insulation R-value	R-49		R402.1.1
<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>		If full thickness over wall top plates	R-38		R402.1.1
<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	Attic Access Hatch	Hatch door insulation	R-49		R402.2.3
<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	Duct Tightness Test (unless all ducts within conditioned space)	Postconstruction total leakage or leakage to outside (CFM per 100ft ²)*	≤4 CFM		R403.2.2
<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>		Rough-in total duct leakage test (CFM per 100ft ²)	≤4 CFM		R403.2.2
<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	Lighting	% of lamps that must be high-efficacy	75%		R404.1
<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	Wood Fireplace	Gasketed doors, outdoor combustion air			R402.4.2
<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	Forced Air Furnace	Programmable thermostat installed			R403.1.1
<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	Heat Pump	Heat pump thermostat installed			R403.1.2
<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	Certificate Posted	Permanent energy label posted on electrical panel			R401.3
Sunroom with thermal Isolation					
<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>		Glazing U-factor	U-0.45		R402.3.5
<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>		Skylight U-factor	U-0.70		
<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>		Wall insulation	R-13		R402.2.12

Montana Builder's Energy Code Checklist (2012 IECC) p 3 of 4

House Address			City		
<input type="checkbox"/> <input type="checkbox"/> N/A	Component	Code Provision	Presc. Code Value	RESChk Tradeoff Value	2009 IECC Code Section
Other Provisions					
<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	All Components	Installed per manufacturer's instructions and building code			R303.2
<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	Basement Wall Exterior Insulation	Exposed insulation protected			R303.2.1
<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	Snowmelt	Snow-melt controls			R403.8
<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	U-factor Labeling	Windows, doors, and skylights certified and labeled			R303.1.3
<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	Insulation Labeling	Installed insulation labeled and observable for inspection			R303.1
<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	Sunroom	Ceiling insulation	R-24		R402.2.12
<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	Recessed Light Fixtures	IC-rated fixtures that meet infiltration criteria			R402.4.4
<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	Hot Water	HW piping insulation under specific conditions	R-3		R403.4
<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>		Circulating HW systems have a automatic or accessible manual controls			R403.4.1
<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	Mech Sys Piping Insul	Carrying fluids > 105 degrees F or < 55 degrees F	R-3		R403.5
<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	Exhaust Openings	Dampers on all outdoor intake & exhaust openings			R403.5
<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	Fenestration Air Leakage	Infiltration rate maximum for windows, skylights, and sliding doors	0.3 CFM/ft ²		R402.4.3
<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>		Infiltration rate maximum for swinging doors	0.5 CFM/ft ²		
<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>		Windows, doors, and skylights air leakage listed and labeled			
<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	Pools and In-ground Spas	Heater accessible manual controls + time switch + cover			R403.9
Duct Tightness Test Results					
Test Date:	House Floor Area Ft ² :	Leakage CFM25:			
Rough-in Test: Total duct leakage in CFM per 100 ft ² of conditioned floor area:					
Postconstruction Test: <u>Leakage to outdoors</u> in CFM per 100 ft ² of conditioned floor area:					
Postconstruction Test: Total duct leakage in CFM per 100 ft ² of conditioned floor area:					
Blower Door Test Results					
Test Date:	House Volume Ft ³ :	House Floor Area Ft ² :			
Measured airflow at 50 Pascals (CFM50):					
Air Change at 50 Pascals (ACH50 = (CFM50 x 60)/Volume):					

Air Barrier and Insulation Installation – Table R402.4.1.1

<input checked="" type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> N/A	Component	Criteria
<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	Air barrier and thermal barrier	A continuous air barrier installed in the building envelope. Exterior thermal envelope contains a continuous air barrier. Breaks or joints in the air barrier sealed. Air-permeable insulation not be used as a sealing material.
<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	Ceiling/attic	The air barrier in any dropped ceiling/soffit aligned with the insulation and any gaps in the air barrier sealed. Access openings, drop-down stair, or knee wall doors to unconditioned attic spaces sealed.
<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	Walls	Corners and headers insulated and the junction of the foundation and sill plate sealed. The junction of the top plate and top of exterior walls sealed. Exterior thermal envelope insulation for framed walls installed in substantial contact and continuous alignment with the air barrier. Knee walls sealed.
<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	Windows, skylights, and doors	The space between window/door jambs and framing and skylights and framing sealed.
<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	Rim joists	Rim joists insulated and include the air barrier.
<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	Floors (above-garage and cantilevered floors)	Insulation installed to maintain permanent contact with underside of subfloor decking.
<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	Crawl space walls	Where provided in lieu of floor insulation, insulation permanently attached to the crawlspace walls. Exposed earth in unvented crawl spaces covered with a Class I vapor retarder with overlapping joints taped.
<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	Shafts, penetrations	Duct shafts, utility penetrations, and flue shafts opening to exterior or unconditioned space sealed.
<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	Narrow cavities	Batts in narrow cavities shall be cut to fit, or narrow cavities shall be filled by insulation that on installation readily conforms to the available cavity space.
<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	Garage separation	Air sealing shall be provided between the garage and conditioned spaces.
<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	Recessed lighting	Recessed light fixtures installed in the building thermal envelope shall be air-tight, IC-rated, and sealed to the drywall.
<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	Plumbing and wiring	Batt insulation shall be cut neatly to fit around wiring and plumbing in exterior walls, or insulation that on installation readily conforms to available space shall extend behind piping and wiring.
<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	Shower/tub on exterior wall	Exterior walls adjacent to showers and tubs shall be insulated and the air barrier installed separating them from the showers and tubs.
<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	Electrical/phone box on exterior walls	The air barrier installed behind electrical or communication boxes or air sealed boxes installed.
<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	HVAC register boots	HVAC register boots that penetrate building thermal envelope sealed to the subfloor or drywall.
<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	Fireplace	An air barrier installed on fireplace walls. Fireplaces have gasketed doors.

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