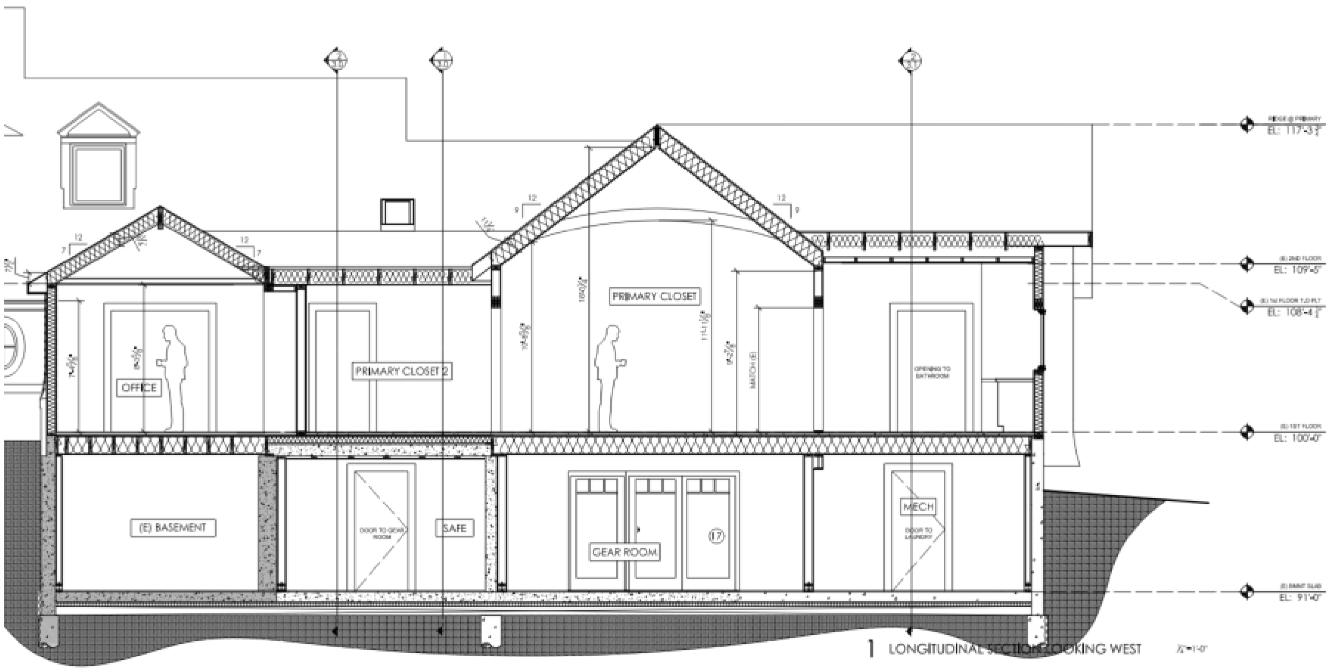
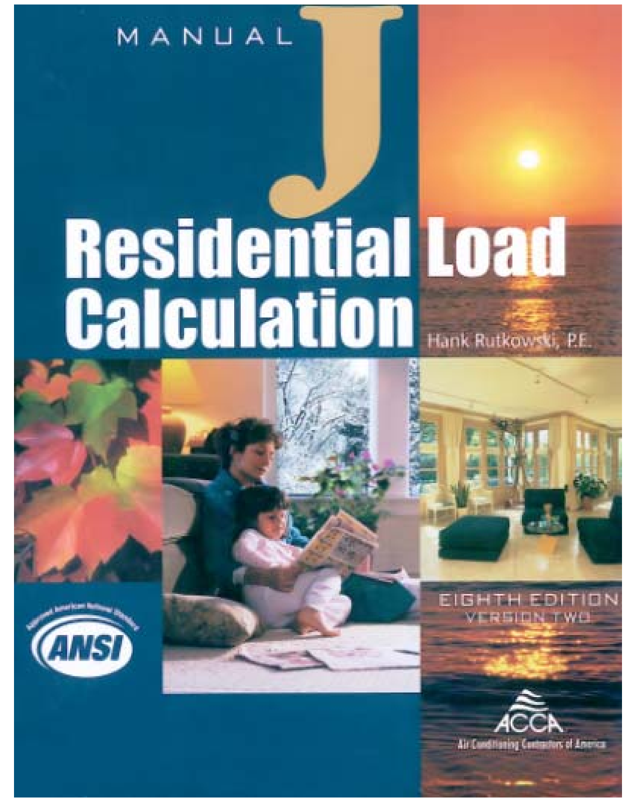
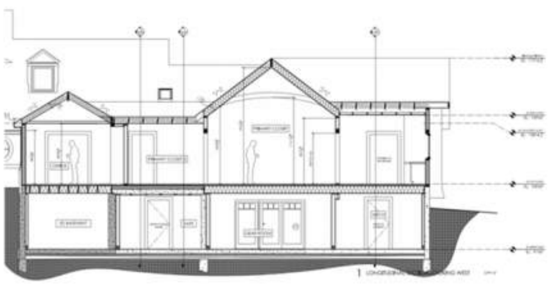
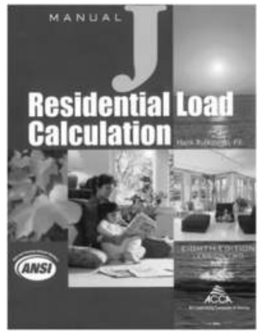
Manual J Requirements/Design





Manual J Requirements/Design





1

Instructor

Gil Rossmiller

- In the construction industry for over 40 years
- ICC – IRC Plumbing & Mechanical Code 2009-2012 Development Committee
- ICC – Commercial Energy Code Development Committee 2015-2018
- ICC – Residential Energy Code Development Committee 2021-2024
- 2003 – 2016
  Building Official
  Parker, Colorado

2

Interactive Class

Please ask questions at any time.

Please let me know when I say something ---
completely
unbelievable

3

The Code

- All Black and White **with nothing but gray** in-between
- I will give you my thoughts
- You will have your thoughts
- The AHJ has the last word

4

R101.3 Intent

This code shall regulate the design and construction of buildings for the effective use and conservation of energy over the useful life of each building. This code is intended to provide flexibility to permit the use of innovative approaches and techniques to achieve this objective.

This code is not intended to abridge safety, health or environmental requirements contained in other applicable codes or ordinances

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R103.2.1 Building thermal envelope depiction

The building thermal envelope shall be represented on the construction documents.

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Climate Zones

TABLE R301.1 CLIMATE ZONES, MOISTURE REGIMES, AND WARM HUMID DESIGNATIONS BY STATE, COUNTY AND TERRITORY[a]

MONTANA
6B (all)

a. Key: A – Moist, B – Dry, C – Marine. Absence of moisture designation indicates moisture regime is irrelevant. Asterisk (*) indicates a Warm Humid location.

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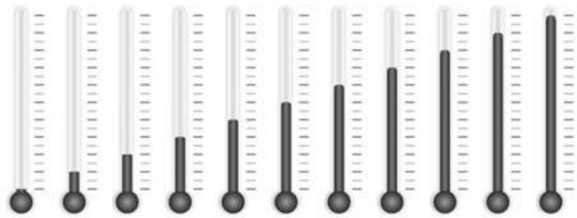
R302.1 Interior design conditions

The interior design temperatures used for heating and cooling load calculations shall be a maximum of 72°F for heating and minimum of 75°F for cooling.



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Tables R301.2(1)

TABLE R301.2(1)

CLIMATIC AND GEOGRAPHIC DESIGN CRITERIA

GROUND SNOW LOAD[o]	WIND DESIGN				SEISMIC DESIGN CATEGORY[f]	SUBJECT TO DAMAGE FROM			ICE BARRIER UNDERLAYMENT REQUIRED[h]	FLOOD HAZARDS[i]	AIR FREEZING INDEX[j]	MEAN ANNUAL TEMP[k]
	Speed[d] (mph)	Topographic Effects[k]	Special wind Region[l]	Windborne debris zone[m]		Weathering[a]	Frost line depth[b]	Termite[c]				
—	—	—	—	—	—	—	—	—	—	—	—	—

MANUAL J DESIGN CRITERIA[n]

Elevation	Altitude correction factor[n]	Summer design grains	Indoor winter design relative humidity	Indoor winter design dry bulb temperature	Outdoor winter design dry bulb temperature	Heating temperature difference
—	—	—	30%	70°	—	—
Latitude	**Daily range**	**Coincident wet bulb**	**Indoor summer design relative humidity**	**Indoor summer design dry bulb temperature**	**Outdoor summer design dry bulb temperature**	**Cooling temperature difference**
—	—	—	50%	75°	—	—

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Compliance paths

R401.2.1 Prescriptive Compliance Option

The Prescriptive Compliance Option requires compliance with Sections R401 through R404.

U-factor, R-value alternative, Total UA

R401.2.2 Total Building Performance Option

The Total Building Performance Option requires compliance with Section R405.

R401.2.3 Energy Rating Index Option

The Energy Rating Index (ERI) Option requires compliance with Section R406

R401.2.4 Tropical Climate Region Option

The Tropical Climate Region Option requires compliance with Section R407.

10

R401.2.5 Additional energy efficiency

This section establishes additional requirements applicable to all compliance approaches to achieve additional energy efficiency.

1. For buildings complying with Section R401.2.1, one of the additional efficiency package options shall be installed according to Section R408.2
2. For buildings complying with Section R401.2.2,the building shall meet one of the following:
   2.1. One of the additional efficiency package options in Section R408.2 shall be installed without including such measures in the proposed design under SectionR405; or
   2.2. The proposed design of the building under Section R405.2 shall have an annual energy cost that is less than or equal to 95 percent of the annual energy cost of the standard reference design.
3. For buildings complying with the Energy Rating Index alternative Section R401.2.3, the Energy Rating Index value shall be at least 5 percent less than the Energy Rating Index target specified in Table R406.5.

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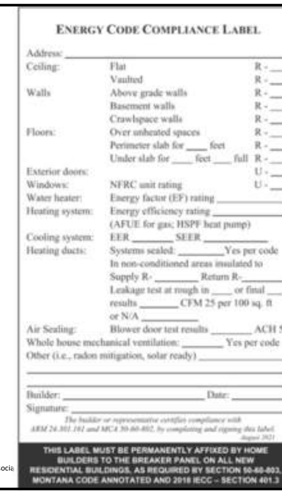
R401.3 Certificate

A permanent certificate shall be completed by the builder or other approved party and posted on a wall in the space where the furnace is located, a utility room or an approved location inside the building. Where located on an electrical panel, the certificate shall not cover or obstruct the visibility of the circuit directory label, service disconnect label or other required labels. The certificate shall indicate the following:



ENERGY CODE COMPLIANCE LABEL

Address: ____________

Ceiling:	Flat	R - ____
	Vaulted	R - ____
Walls	Above grade walls	R - ____
	Basement walls	R - ____
	Crawlspace walls	R - ____
Floors:	Over unheated spaces	R - ____
	Perimeter slab for ____ feet	R - ____
	Under slab for ____ feet ____ full	R - ____
Exterior doors:		U - ____
Windows:	NFRC unit rating	U - ____
Water heater:	Energy factor (EF) rating ____________	
Heating system:	Energy efficiency rating ____________ (AFUE for gas; HSPF heat pump)	
Cooling system:	EER ________ SEER ____________	
Heating ducts:	Systems sealed: ________Yes per code In non-conditioned areas insulated to Supply R- ________ Return R-________ Leakage test at rough in ____ or final ____ results ________CFM 25 per 100 sq. ft or N/A ____________	
Air Sealing:	Blower door test results ________ ACH 50	

Whole house mechanical ventilation: ________ Yes per code

Other (i.e., radon mitigation, solar ready) ____________

Builder: ____________ Date: ________

Signature: ____________

The builder or representative certifies compliance with ARM 24.301.161 and MCA 50-60-802, by completing and signing this label. August 2021

THIS LABEL MUST BE PERMANENTLY AFFIXED BY HOME BUILDERS TO THE BREAKER PANEL ON ALL NEW RESIDENTIAL BUILDINGS, AS REQUIRED BY SECTION 50-60-803, MONTANA CODE ANNOTATED AND 2018 IECC – SECTION 401.3

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R402 Building Thermal Envelope

R402.1 General

The building thermal envelope shall comply with the requirements of Sections R402.1.1 through R402.1.5.

Exceptions:

1. The following low-energy buildings, or portions thereof, separated from the remainder of the building by *building thermal envelope* assemblies complying with this section shall be exempt from the building thermal envelope provisions of Section R402.

1.1. Those with a peak design rate of energy usage less than 3.4 Btu/h × ft 2 or 1.0 watt/ft2 of floor area for space-conditioning purposes.

1.2. Those that do not contain conditioned space.

2. Log homes designed in accordance with ICC 400

 13

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R402.1.1 Vapor retarder

Wall assemblies in the building thermal envelope shall comply with the vapor retarder requirements of Section R702.7 of the International Residential Code or Section 1404.3 of the International Building Code, as applicable.

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R402 Building Thermal Envelope

R402.1.2 Insulation and fenestration criteria

The building thermal envelope shall meet the requirements of Table R402.1.2, based on the climate zone specified in Chapter 3. Assemblies shall have a U-factor equal to or less than that specified in Table R402.1.2. Fenestration shall have a U-factor and glazed fenestration SHGC equal to or less than that specified in Table R402.1.2.

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Montana Amendment

(c) Table R402.1.2, INSULATION AND FENESTRATION REQUIREMENTS BY COMPONENT, is amending requirements for climate zone 6 as WOOD FRAMED WALL R-VALUE 'R-21 or R-20 + R-5ci or R-13 + R-10ci or R-15ci.'

(d) Table R402.1.4, EQUIVALENT *U*-FACTORS, is amending requirements as shown below in the table:

Climate Zone	Fenes-tration *U*-*Factor*	Sky-light *U*-Factor	Ceiling *U*-Factor	Frame Wall *U*-Factor	Mass Wall *U*-Factor	Floor *U*-Factor	Base-ment Wall *U*-Factor	Crawl Space Wall *U*-Factor
6	0.30	0.55	0.026	0.045	0.060	0.033	0.050	0.055

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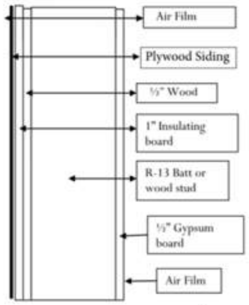
R402 Building Thermal Envelope



	R-value at Insulation	R-value at Stud
Air Film	00.17	00.17
Plywood Siding	00.59	00.59
½" Wood	00.81	00.81
1" Insulating board	03.57	03.57
R-13 Batt or wood stud	13.00	04.55
½" Gypsum board	00.45	00.45
Air Film	00.68	00.68
Totals	19.27	10.82

Assume a framing factor of 20% (The area of the wall that is wood)

Average R= (0.80 x 19.27) + (0.20 x 10.82) = 15.41 + 2.16 = 17.57

U-value = 1/17.57 = 0.057

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R402 Building Thermal Envelope

R402.1.3 R-value alternative

Assemblies with R-value of insulation materials equal to or greater than that specified in Table R402.1.3 shall be an alternative to the U-factor in Table R402.1.2

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R402 Building Thermal Envelope

TABLE R402.1.3
INSULATION MINIMUM R-VALUES AND FENESTRATION REQUIREMENTS BY COMPONENT[a]

CLIMATE ZONE	FENESTRATION U-FACTOR[b, i]	SKYLIGHT[b] U-FACTOR	GLAZED FENESTRATION SHGC[b, e]	CEILING R-VALUE	WOOD FRAME WALL R-VALUE[g]	MASS WALL R-VALUE[i]	FLOOR R-VALUE	BASEMENT[c, g] WALL R-VALUE	SLAB[d] R-VALUE & DEPTH	CRAWL SPACE[c, g] WALL R-VALUE
0	NR	0.75	0.25	30	13 or 0&10ci	3/4	13	0	0	0
1	NR	0.75	0.25	30	13 or 0&10ci	3/4	13	0	0	0
2	0.40	0.65	0.25	49	13 or 0&10ci	4/6	13	0	0	0
3	.30	0.55	0.25	49	20 or 13&5ci[h] or 0&15ci[h]	8/13	19	5ci or 13[f]	10ci, 2 ft	5ci or 13[f]
4 except Marine	.30	0.55	0.40	60	30 or 20&5ci[h] or 13&10ci[h] or 0&20ci[h]	8/13	19	10ci or 13	10ci, 4 ft	10ci or 13
5 and Marine 4	0.30[j]	0.55	0.40	60	30 or 20&5ci[h] or 13&10ci[h] or 0&20ci[h]	13/17	30	15ci or 19 or 13&5ci	10ci, 4 ft	15ci or 19 or 13&5ci
6	0.30[j]	0.55	NR	60		15/20	30	15ci or 19 or 13&5ci	10ci, 4 ft	15ci or 19 or 13&5ci
7 and 8	0.30[j]	0.55	NR	60	30 or 20&5ci[h] or 13&10ci[h] or 0&20ci[h]	19/21	38	15ci or 19 or 13&5ci	10ci, 4 ft	15ci or 19 or 13&5ci

WOOD FRAMED WALL R-VALUE 'R-21 or R-20 + R-5ci or R-13 + R-10ci or R-15ci.'

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R402.2 Specific insulation requirements

R402.2.1 Ceilings with attics

Where Section R402.1.3 requires R-49 insulation in the ceiling or attic, installing R-38 over 100 percent of the ceiling or attic area requiring insulation shall satisfy the requirement for R-49 insulation wherever the full height of uncompressed R-38 insulation extends over the wall top plate at the eaves.

Where Section R402.1.3 requires R-60 insulation in the ceiling or attic, installing R-49 over 100 percent of the ceiling or attic area requiring insulation shall satisfy the requirement for R-60 insulation wherever the full height of uncompressed R-49 insulation extends over the wall top plate at the eaves.

This reduction shall not apply to the insulation and fenestration criteria in Section R402.1.2 and the Total UA alternative in Section R402.1.5

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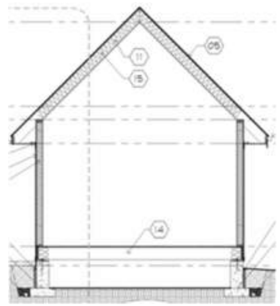
Montana Amendment

(e) Subsection R402.2.2, Ceilings Without Attics, is deleted and replaced with the following: "Where Table R402.1.3 would require insulation levels above R-30 and the design of the roof/ceiling assembly does not allow sufficient space for the required insulation, the minimum required insulation for such roof/ceiling assemblies shall be R-30. This reduction of insulation from the requirements of Table R402.1.3, shall be limited to 250 square feet or ten percent of the total insulated ceiling area, whichever is less. This reduction shall not apply to the U-factor alternative approach in Section R402.1.4, and the total UA alternative in Section R402.1.5."



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R402.2 Specific insulation requirements

R402.2.3 Eave baffle

For air-permeable insulation in vented attics, a baffle shall be installed adjacent to soffit and eave vents. Baffles shall maintain a net free area opening equal to or greater than the size of the vent. The baffle shall extend over the top of the attic insulation. The baffle shall be permitted to be any solid material. The baffle shall be installed to the outer edge of the exterior wall top plate so as to provide maximum space for attic insulation coverage over the top plate.

<u>Where soffit venting is not continuous, baffles shall be installed continuously to prevent ventilation air in the eave soffit from bypassing the baffle</u>

 22

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R402.2 Specific insulation requirements

R402.2.4 Access hatches and doors

Access hatches and doors from conditioned to unconditioned spaces such as attics and crawl spaces shall be insulated to the same R-value required by Table R402.1.3 for the wall or ceiling in which they are installed

Exceptions:

 23

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R402.2 Specific insulation requirements

R402.2.4.1 Access hatches and door insulation installation and retention

Vertical or horizontal access hatches and doors from conditioned spaces to unconditioned spaces such as attics and crawl spaces shall be weatherstripped.

Access that prevents damaging or compressing the insulation shall be provided to all equipment.

Where loose-fill insulation is installed, a wood-framed or equivalent baffle, retainer, or dam shall be installed to prevent loose-fill insulation from spilling into living space from higher to lower sections of the attic and from attics covering conditioned spaces to unconditioned spaces. The baffle or retainer shall provide a permanent means of maintaining the installed R-value of the loose-fill insulation

 24

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R402.2 Specific insulation requirements

R402.2.7 Floors

Floor cavity insulation shall comply with one of the following:

1. Installation shall be installed to maintain permanent contact with the underside of the subfloor decking in accordance with manufacturer instructions to maintain required R-value or readily fill the available cavity space

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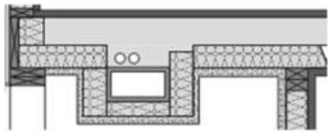
R402.2 Specific insulation requirements

2. Floor framing cavity insulation shall be permitted to be in contact with the top side of sheathing separating the cavity and the unconditioned space below. Insulation shall extend from the bottom to the top of all perimeter floor framing members and the framing members shall be air sealed



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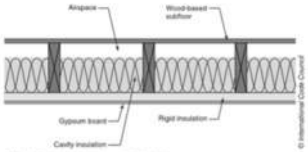
R402.2 Specific insulation requirements

3. A combination of cavity and continuous insulation shall be installed so that the cavity insulation is in contact with the top side of the continuous insulation that is installed on the underside of the floor framing separating the cavity and the unconditioned space below. The combined R-value of the cavity and continuous insulation shall equal the required R-value for floors. Insulation shall extend from the bottom to the top of all perimeter floor framing members and the framing members shall be air sealed.



Option for floor insulation above rigid insulation

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R402.2 Specific insulation requirements

R402.2.8 Basement walls
Basement walls shall be insulated in accordance with Table R402.1.3.

Exception:

Basement walls associated with unconditioned basements where all of the following requirements are met:

Exception:

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R402.2 Specific insulation requirements

R402.2.8 Basement walls

Exception: Basement walls associated with unconditioned basements where all of the following requirements are met:

1.The floor overhead, including the underside stairway stringer leading to the basement, is insulated in accordance with Section R402.1.3 and applicable provisions of Sections R402.2 and R402.2.7.

2.There are no uninsulated duct, domestic hot water, or hydronic heating surfaces exposed to the basement.

3.There are no HVAC supply or return diffusers serving the basement.

4.The walls surrounding the stairway and adjacent to conditioned space are insulated in accordance with Section R402.1.3 and applicable provisions of Section R402.2.

5.The door(s) leading to the basement from conditioned spaces are insulated in accordance with Section R402.1.3 and applicable provisions of Section R402.2, and weatherstripped in accordance with Section R402.4.

6.The building thermal envelope separating the basement from adjacent conditioned spaces complies with Section R402.4.

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R402.2 Specific insulation requirements

R402.2.8.1 Basement wall insulation installation

Where basement walls are insulated, the insulation shall be installed from the top of the basement wall down to 10 feet below grade or to the basement floor, whichever is less.

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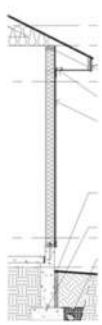
R402.2 Specific insulation requirements

R402.2.9 Slab-on-grade floors

Slab-on-grade floors with a floor surface less than 12 inches below grade shall be insulated in accordance with Table R402.1.3.

Exception

Slab-edge insulation is not required in jurisdictions designated by the code official as having a very heavy termite infestation



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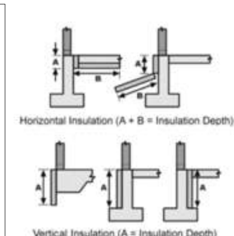
R402.2 Specific insulation requirements

R402.2.9.1 Slab-on-grade floor insulation installation

Where installed, the insulation shall extend downward from the top of the slab on the outside or inside of the foundation wall. Insulation located below grade shall be extended the distance provided in Table R402.1.3 or the distance of the proposed design, as applicable, by any combination of vertical insulation, insulation extending under the slab or insulation extending out from the building. Insulation extending away from the building shall be protected by pavement or by not less than 10 inches of soil.

The top edge of the insulation installed between the exterior wall and the edge of the interior slab shall be permitted to be cut at a 45-degree angle away from the exterior wall.



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R402.2 Specific insulation requirements

R402.2.10 Crawl space wall
Crawl space walls shall be insulated in accordance with Table R402.1.3.

Exception

Crawl space walls associated with a crawl space that is vented to the outdoors and the floor over-head is insulated in accordance with Table R402.1.3 and Section R402.2.7.

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Montana Amendment

(f) Subsection R402.2.10, Crawl Space Walls, is deleted and replaced with the following: "As an alternative to insulating floors over crawl spaces, crawl space walls shall be permitted to be insulated when the crawl space is not vented to the outside.

Temporary crawl space vent openings are allowed during construction for crawl spaces that have insulated crawl space walls.

These temporary crawl space vent openings shall be closed, sealed, and insulated to the same R-value of the surrounding crawl space wall insulation once construction is complete and prior to the time that the final building inspection would occur.

Crawl space wall insulation shall be permanently fastened to the wall and shall extend downward from the floor, the entire height of the crawl space wall.

Exposed earth in unvented crawl space foundations shall be covered with a continuous Class I vapor retarder.

All joints of the vapor retarder shall overlap six inches and be sealed or taped.

The edges of the vapor retarder shall extend at least six inches up the stem wall and shall be attached and sealed to the stem wall."

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R402.2 Specific insulation requirements

R402.2.10.1 Crawl space wall insulation installations

Where crawl space wall insulation is installed, it shall be permanently fastened to the wall and shall extend downward from the floor to the finished grade elevation and then vertically or horizontally for not less than an additional 24 inches.

Exposed earth in unvented crawl space foundations shall be covered with a continuous Class I vapor retarder in accordance with the International Building Code or International Residential Code, as applicable.

Joints of the vapor retarder shall overlap by 6 inches and be sealed or taped. The edges of the vapor retarder shall extend not less than 6 inches up stem walls and shall be attached to the stem walls.

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R402.2 Specific insulation requirements

R402.2.12 Sunroom and heated garage insulation

Sunrooms enclosing conditioned space and heated garages shall meet the insulation requirements of this code.

Exception

For sunrooms and heated garages provided thermal isolation, and enclosed conditioned space, the following exceptions to the insulation requirements of this code shall apply:

1. The minimum ceiling insulation R-values shall be R-19 in Climate Zones 0 through 4 and R-24 in Climate Zones 5 through 8.

2. The minimum wall insulation R-value shall be R-13 in all climate zones. Walls separating a sunroom or heated garage with thermal isolation from conditioned space shall comply with the building thermal envelope requirements of this code.

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R402.4 Air leakage

R402.4 Air leakage

The building thermal envelope shall be constructed to limit air leakage in accordance with the requirements of Sections R402.4.1 through R402.4.5.

R402.4.1 Building thermal envelope

The building thermal envelope shall comply with Sections R402.4.1.1 through R402.4.1.3. The sealing methods between dissimilar materials shall allow for differential expansion and contraction.

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R402.4 Air leakage

R402.4.1.1 Installation

The components of the building thermal envelope as indicated in Table R402.4.1.1 shall be installed in accordance with the manufacturer's instructions and the criteria indicated in Table R402.4.1.1, as applicable to the method of construction.

Where required by the code official, an approved third party shall inspect all components and verify compliance.

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R402.4 Air leakage

TABLE R402.4.1.1 AIR BARRIER, AIR SEALING AND INSULATION INSTALLATION [a]		
COMPONENT	AIR BARRIER CRITERIA	INSULATION INSTALLATION CRITERIA
General requirements	A continuous air barrier shall be installed in the building envelope. Breaks or joints in the air barrier shall be sealed.	Air-permeable insulation shall not be used as a sealing material.

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TABLE R402.4.1.1 AIR BARRIER, AIR SEALING AND INSULATION INSTALLATION [a]		
COMPONENT	AIR BARRIER CRITERIA	INSULATION INSTALLATION CRITERIA
Ceiling/attic	The air barrier in any dropped ceiling or soffit shall be aligned with the insulation and any gaps in the air barrier shall be sealed. Access openings, drop down stairs or knee wall doors to unconditioned attic spaces shall be sealed.	The insulation in any dropped ceiling/soffit shall be aligned with the air barrier.

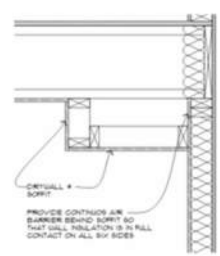

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TABLE R402.4.1.1
AIR BARRIER, AIR SEALING AND INSULATION INSTALLATION [a]

COMPONENT	AIR BARRIER CRITERIA	INSULATION INSTALLATION CRITERIA
Walls	The junction of the foundation and sill plate shall be sealed. The junction of the top plate and the top of exterior walls shall be sealed. Knee walls shall be sealed.	Cavities within corners and headers of frame walls shall be insulated by completely filling the cavity with a material having a thermal resistance, R-value, of not less than R-3 per inch. Exterior thermal envelope insulation for framed walls shall be installed in substantial contact and continuous alignment with the air barrier.

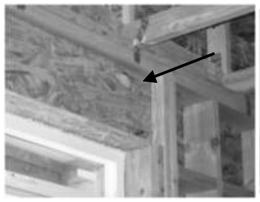


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TABLE R402.4.1.1
AIR BARRIER, AIR SEALING AND INSULATION INSTALLATION [a]

COMPONENT	AIR BARRIER CRITERIA	INSULATION INSTALLATION CRITERIA
Windows, skylights and doors	The space between framing and skylights, and the jambs of windows and doors, shall be sealed.	—

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TABLE R402.4.1.1
AIR BARRIER, AIR SEALING AND INSULATION INSTALLATION [a]

COMPONENT	AIR BARRIER CRITERIA	INSULATION INSTALLATION CRITERIA
Rim joists	Rim joists shall include an exterior air barrier.[b] The junctions of the rim board to the sill plate and the rim board and the subfloor shall be air sealed.	Rim joists shall be insulated so that the insulation maintains permanent contact with the exterior rim board.[b]


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TABLE R402.4.1.1
AIR BARRIER, AIR SEALING AND INSULATION INSTALLATION [a]

COMPONENT	AIR BARRIER CRITERIA	INSULATION INSTALLATION CRITERIA
Floors, including cantilevered floors and floors above garages	The air barrier shall be installed at any exposed edge of insulation.	Floor framing cavity insulation shall be installed to maintain permanent contact with the underside of subfloor decking. Alternatively, floor framing cavity insulation shall be in contact with the top side of sheathing, or continuous insulation installed on the underside of floor framing and extending from the bottom to the top of all perimeter floor framing members.

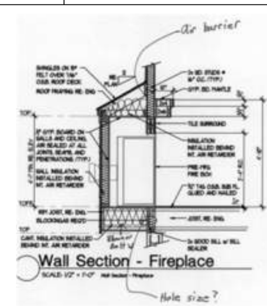

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TABLE R402.4.1.1 AIR BARRIER, AIR SEALING AND INSULATION INSTALLATION [a]		
COMPONENT	AIR BARRIER CRITERIA	INSULATION INSTALLATION CRITERIA
Basement crawl space and slab foundations	Exposed earth in unvented crawl spaces shall be covered with a Class I vapor retarder/air barrier in accordance with Section R402.2.10. Penetrations through concrete foundation walls and slabs shall be air sealed. Class 1 vapor retarders shall not be used as an air barrier on below-grade walls and shall be installed in accordance with Section R702.7 of the International Residential Code.	Crawl space insulation, where provided instead of floor insulation, shall be installed in accordance with Section R402.2.10. Conditioned basement foundation wall insulation shall be installed in accordance with Section R402.2.8.1. Slab-on-grade floor insulation shall be installed in accordance with Section R402.2.10.

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TABLE R402.4.1.1 AIR BARRIER, AIR SEALING AND INSULATION INSTALLATION [a]		
COMPONENT	AIR BARRIER CRITERIA	INSULATION INSTALLATION CRITERIA
Shafts, penetrations	Duct and flue shafts to exterior or unconditioned space shall be sealed. Utility penetrations of the air barrier shall be caulked, gasketed or otherwise sealed and shall allow for expansion, contraction of materials and mechanical vibration.	Insulation shall be fitted tightly around utilities passing through shafts and penetrations in the building thermal envelope to maintain required R-value.

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TABLE R402.4.1.1 AIR BARRIER, AIR SEALING AND INSULATION INSTALLATION [a]		
COMPONENT	AIR BARRIER CRITERIA	INSULATION INSTALLATION CRITERIA
Narrow cavities	Narrow cavities of 1 inch or less that are not able to be insulated shall be air sealed.	Batts to be installed in narrow cavities shall be cut to fit or narrow cavities shall be filled with insulation that on installation readily conforms to the available cavity space.

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TABLE R402.4.1.1 AIR BARRIER, AIR SEALING AND INSULATION INSTALLATION [a]		
COMPONENT	AIR BARRIER CRITERIA	INSULATION INSTALLATION CRITERIA
Garage separation	Air sealing shall be provided between the garage and conditioned spaces.	Insulated portions of the garage separation assembly shall be installed in accordance with Sections R303 and R402.2.7.

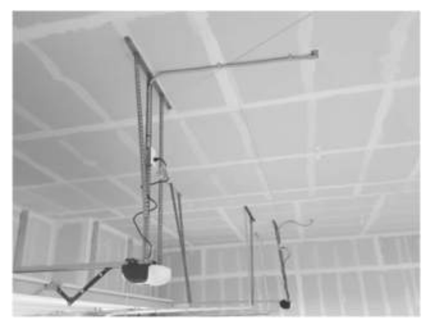

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TABLE R402.4.1.1
AIR BARRIER, AIR SEALING AND INSULATION INSTALLATION [a]

COMPONENT	AIR BARRIER CRITERIA	INSULATION INSTALLATION CRITERIA
Recessed lighting	Recessed light fixtures installed in the building thermal envelope shall be air sealed in accordance with Section R402.4.5.	Recessed light fixtures installed in the building thermal envelope shall be airtight and IC rated, and shall be buried or surrounded with insulation.

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TABLE R402.4.1.1
AIR BARRIER, AIR SEALING AND INSULATION INSTALLATION [a]

COMPONENT	AIR BARRIER CRITERIA	INSULATION INSTALLATION CRITERIA
Plumbing, wiring or other obstructions	All holes created by wiring, plumbing or other obstructions in the air barrier assembly shall be air sealed.	Insulation shall be installed to fill the available space and surround wiring, plumbing, or other obstructions, unless the required R-value can be met by installing insulation and air barrier systems completely to the exterior side of the obstructions.

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TABLE R402.4.1.1
AIR BARRIER, AIR SEALING AND INSULATION INSTALLATION [a]

COMPONENT	AIR BARRIER CRITERIA	INSULATION INSTALLATION CRITERIA
Shower/tub on exterior wall	The air barrier installed at exterior walls adjacent to showers and tubs shall separate the wall from the shower or tub.	Exterior walls adjacent to showers and tubs shall be insulated.

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TABLE R402.4.1.1
AIR BARRIER, AIR SEALING AND INSULATION INSTALLATION [a]

COMPONENT	AIR BARRIER CRITERIA	INSULATION INSTALLATION CRITERIA
Electrical/phone box on exterior walls	The air barrier shall be installed behind electrical and communication boxes. **Alternatively**, air-sealed boxes shall be installed.	—

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TABLE R402.4.1.1
AIR BARRIER, AIR SEALING AND INSULATION INSTALLATION [a]

COMPONENT	AIR BARRIER CRITERIA	INSULATION INSTALLATION CRITERIA
HVAC register boots	HVAC supply and return register boots that penetrate building thermal envelope shall be sealed to the subfloor, wall covering or ceiling penetrated by the boot.	—

TABLE R402.4.1.1
AIR BARRIER, AIR SEALING AND INSULATION INSTALLATION [a]

COMPONENT	AIR BARRIER CRITERIA	INSULATION INSTALLATION CRITERIA
Concealed sprinklers	Where required to be sealed, concealed fire sprinklers shall only be sealed in a manner that is recommended by the manufacturer. Caulking or other adhesive sealants shall not be used to fill voids between fire sprinkler cover plates and walls or ceilings.	—

a. Inspection of log walls shall be in accordance with the provisions of ICC 400.
b. Air barrier and insulation full enclosure is not required in unconditioned/ventilated attic spaces and at rim joists.

R402.4 Air leakage

R402.4.1.2 Testing

The building or dwelling unit shall be tested for air leakage. The maximum air leak-age rate for any building or dwelling unit under any compliance path shall not exceed 5.0 air changes per hour **or** 0.28 cubic feet per minute (CFM) per square foot of dwelling unit enclosure area. Testing shall be conducted in accordance with ANSI/RESNET/ICC 380, ASTM E779 or ASTM E1827 and reported at a pressure of 0.2 inch w.g. (50 Pascals)

Exception….

R402.4 Air leakage

Exception

For heated, attached private garages and heated, detached private garages accessory to one-and two-family dwellings and townhouses not more than three stories above grade plane in height, building envelope tightness and insulation installation shall be considered acceptable where the items in Table R402.4.1.1, applicable to the method of construction, are field verified.

Where required by the code official, an approved third party independent from the installer shall inspect both air barrier and insulation installation criteria. Heated, attached private garage space and heated, detached private garage space shall be thermally isolated from all other habitable, conditioned spaces in accordance with Sections R402.2.12 and R402.3.5, as applicable

Montana Amendment

(g) Subsection R402.4.1.2, Testing, is deleted and replaced with the following: The building or dwelling unit shall be tested and verified as having an air leakage rate of not exceeding four air changes per hour in Climate Zone 6. Testing shall be conducted with a blower door at a pressure of 0.2 inches w.g. (50 Pascals).
Where required by the code official, testing shall be conducted by an approved party. A written report of the results of the test shall be signed by the party conducting the test and provided to the code official. Testing shall be performed at any time after creation of all penetrations of the building thermal envelope.
During testing:
"(i) exterior windows and doors, fireplace and stove doors shall be closed, but not sealed;
"(ii) dampers shall be closed, but not sealed, including exhaust, intake, makeup air, back draft and flue dampers;
"(iii) interior doors shall be open;
"(iv) exterior openings for continuous ventilation systems and heat recovery ventilators shall be closed and sealed;
"(v) heating and cooling system(s) shall be turned off;
"(vi) "B" or "L" vents, combustion air vents, and dryer vents shall be sealed; and
"(vii) supply and return registers, where installed at the time of test, shall by fully open.

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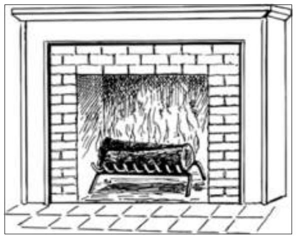
R402.4 Air leakage

R402.4.2 Fireplaces

New wood-burning fireplaces shall have tight-fitting flue dampers or doors, and outdoor combustion air. Where using tight-fitting doors on factory-built fireplaces listed and labeled in accordance with UL 127, the doors shall be tested and listed for the fireplace.



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R402.4 Air leakage

R402.4.4 Rooms containing fuel-burning appliances

In Climate Zones 3 through 8, where open combustion air ducts provide combustion air to open combustion fuel burning appliances, the appliances and combustion air opening shall be located outside the building thermal envelope or enclosed in a room, isolated from inside the thermal envelope. Such rooms shall be sealed and insulated in accordance with the envelope requirements of Table R402.1.2, where the walls, floors and ceilings shall meet not less than the basement wall R-value requirement. The door into the room shall be fully gasketed and any water lines and ducts in the room insulated in accordance with Section R403. The combustion air duct shall be insulated where it passes through conditioned space to a minimum of R-8.

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R402.4 Air leakage

R402.4.5 Recessed lighting

Recessed luminaires installed in the building thermal envelope shall be sealed to limit air leakage between conditioned and unconditioned spaces. Recessed luminaires shall be IC-rated and labeled as having an air leakage rate of not greater than 2.0 cfm when tested in accordance with ASTM E283 at a pressure differential of 1.57 psf.

Recessed luminaires shall be sealed with a gasket or caulked between the housing and the interior wall or ceiling covering

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R402.4 Air leakage

R402.4.6 Electrical and communication outlet boxes (air-sealed boxes)

Electrical and communication outlet boxes installed in the building thermal envelope shall be sealed to limit air leakage between conditioned and unconditioned spaces. Electrical and communication outlet boxes shall be tested in accordance with NEMA OS 4 , Requirements for Air-Sealed Boxes for Electrical and Communication Applications, and shall have an air leak-age rate of not greater than 2.0 cubic feet per minute at a pressure differential of 1.57 psf (75 Pa).

Electrical and communication outlet boxes shall be marked “NEMA OS 4” or “OS 4” in accordance with NEMA OS 4.

Electrical and communication outlet boxes shall be installed per the manufacturer’s instructions and with any supplied components required to achieve compliance with NEMA OS 4

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R403.1 Controls

R403.1.1 Programmable thermostat

The thermostat controlling the primary heating or cooling system of the dwelling unit shall be capable of controlling the heating and cooling system on a daily schedule to maintain different temperature set points at different times of day and different days of the week.

This thermostat shall include the capability to set back or temporarily operate the system to maintain zone temperatures of not less than 55°F to not greater than 85°F.

The thermostat shall be programmed initially by the manufacturer with a heating temperature setpoint of not greater than 70°F and a cooling temperature setpoint of not less than 78°F

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R403.1 Controls

R403.1.2 Heat pump supplementary heat

Heat pumps having supplementary electric-resistance heat shall have controls that, except during defrost, prevent supplemental heat operation when the heat pump compressor can meet the heating load

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R403.3 Ducts

R403.3.1 Ducts located outside conditioned space

Supply and return ducts located outside conditioned space shall be insulated to an R-value of not less than R-8 for ducts 3 inches in diameter and larger and not less than R-6 for ducts smaller than 3 inches in diameter.

Ducts buried beneath a building shall be insulated as required per this section or have an equivalent thermal distribution efficiency.

Underground ducts utilizing the thermal distribution efficiency method shall be listed and labeled to indicate the R-value equivalency.

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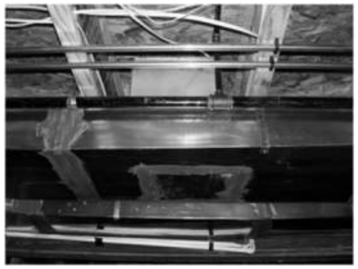
R403.3 Ducts

R403.3.2 Ducts located in conditioned space

For ductwork to be considered inside a conditioned space, it shall comply with one of the following:

1. The duct system shall be located completely within the continuous air barrier and within the building thermal envelope.



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R403.3 Ducts

2. Ductwork in ventilated attic spaces shall be buried within ceiling insulation in accordance with Section R403.3.3 and all of the following conditions shall exist:

2.1. The air handler is located completely within the continuous air barrier and within the building thermal envelope.

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R403.3 Ducts

2.2. The duct leakage, as measured either by a rough-in test of the ducts or a post-construction total system leakage test to outside the building thermal envelope in accordance with Section R403.3.6, is less than or equal to 1.5 cubic feet per minute per 100 square feet of conditioned floor area served by the duct system.

2.3. The ceiling insulation R-value installed against and above the insulated duct is greater than or equal to the proposed ceiling insulation R-value, less the R-value of the insulation on the duct.

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R403.3 Ducts

3. Ductwork in floor cavities located over unconditioned space shall comply with all of the following:

3.1. A continuous air barrier installed between unconditioned space and the duct.

3.2. Insulation installed in accordance with Section R402.2.7.

3.3. A minimum R-19 insulation installed in the cavity width separating the duct from unconditioned space.

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R403.3 Ducts

4. Ductwork located within exterior walls of the building thermal envelope shall comply with the following:
   - 4.1. A continuous air barrier installed between unconditioned space and the duct.
   - 4.2. Minimum R-10 insulation installed in the cavity width separating the duct from the outside sheathing.
   - 4.3. The remainder of the cavity insulation shall be fully insulated to the drywall side.

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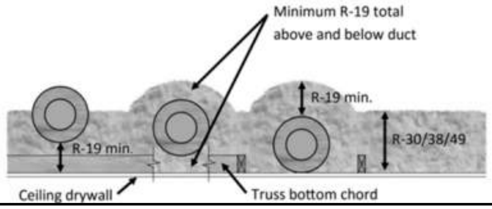
R403.3 Ducts

R403.3.3 Ducts buried within ceiling insulation

Where supply and return air ducts are partially or completely buried in ceiling insulation, such ducts shall comply with all of the following:

1. The supply and return ducts shall have an insulation R-value not less than R-8.
2. At all points along each duct, the sum of the ceiling insulation R-value against and above the top of the duct, and against and below the bottom of the duct, shall be not less than R-19, excluding the R-value of the duct insulation.
3. In Climate Zones 0A, 1A, 2A and 3A, the supply ducts shall be completely buried within ceiling insulation, insulated to an R-value of not less than R-13 and in compliance with the vapor retarder requirements of Section 604.11 of the International Mechanical Code or Section M1601.4.6 of the International Residential Code, as applicable.



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R403.3 Ducts

R403.3.4 Sealing

Ducts, air handlers and filter boxes shall be sealed. Joints and seams shall comply with either the International Mechanical Code or International Residential Code, as applicable.

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R403.3.4.1 Sealed air handler

Air handlers shall have a manufacturer's designation for an air leakage of not greater than 2 percent of the design airflow rate when tested in accordance with ASHRAE 193.

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R403.3 Ducts

R403.3.5 Duct testing

Ducts shall be pressure tested in accordance with ANSI/RESNET/ICC 380 or ASTM E1554 to determine air leakage by one of the following methods:

1. Rough-in test: Total leakage shall be measured with a pressure differential of 0.1 inch w.g. (25 Pa) across the system, including the manufacturer's air handler enclosure if installed at the time of the test. Registers shall be taped or otherwise sealed during the test.

2. Postconstruction test: Total leakage shall be measured with a pressure differential of 0.1 inch w.g. (25 Pa) across the entire system, including the manufacturer's air handler enclosure. Registers shall be taped or otherwise sealed during the test.

Exception: A duct air-leakage test shall not be required for ducts serving ventilation systems that are not integrated with ducts serving heating or cooling systems

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Montana Amendment

(i) Subsection R403.3.7,
Exception: Building framing cavities may be used for return ducts if there is no atmospherically vented furnace, boiler, or water heater located in the house outside of a sealed and insulated room that is isolated from inside the thermal envelope and if the duct system has been tested as having a maximum total leakage not greater than 4 cfm/(100?)SF.
The room walls, floor, and ceilings shall be insulated in accordance with the basement wall requirements of Table R402.1.3.
A duct air leakage test shall not be required where the ducts and air handlers are located entirely within the building thermal envelope.

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R403.6 Mechanical ventilation

The buildings complying with Section R402.4.1 shall be provided with ventilation that complies with the requirements of Section M1505 of the International Residential Code or International Mechanical Code, as applicable, or with other approved means of ventilation.

Outdoor air intakes and exhausts shall have automatic or gravity dampers that close when the ventilation system is not operating.

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Montana 2021 IMC Amendment

(h) Table 403.3.1.1 is amended by the addition of a footnote "i". Footnote "i" is to be

referenced in the table at, "Private Dwellings, Single and Multiple". The footnote at the end of the table should be as follows: "

i. Every dwelling unit shall have installed a minimum 100 CFM exhaust fan controlled by either an automatic timer or humidistat. Structures built to the provisions of the International Residential Code may provide mechanical ventilation per Section M1505 of the International Residential Code."

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2021 IMC

- **403.3.2 Group R-2, R-3 and R-4 occupancies, three stories and less**
- The design of local exhaust systems and ventilation systems for outdoor air in Group R-2, R-3 and R-4 occupancies three stories and less in height above grade plane shall comply with Sections 403.3.2.1 through 403.3.2.5.

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2021 IMC

403.3.2.1 Outdoor air for dwelling units

An outdoor air ventilation system consisting of a mechanical exhaust system, supply system or combination thereof shall be installed for each dwelling unit. Local exhaust or supply systems, including outdoor air ducts connected to the return side of an air handler, are permitted to serve as such a system. The outdoor air ventilation system shall be designed to provide the required rate of outdoor air continuously during the period that the building is occupied. The minimum continuous outdoor airflow rate shall be determined in accordance with Equation 4-9

$Q_{OA}=0.01^{A}floor+7.5(N_{br}+1)$

where:

Q_{OA} =outdoor airflow rate, cfm

A_{floor} =floor area, ft^2

N_{br} =number of bedrooms; not to be less than one

Exceptions

1. The outdoor air ventilation system is not required to operate continuously where the system has controls that enable operation for not less than 1 hour of each 4-hour period. The average outdoor airflow rate over the 4-hour period shall be not less than that prescribed by Equation 4-9.

2. The minimum mechanical ventilation rate determined in accordance with Equation 4-9 shall be reduced by 30 percent provided that both of the following conditions apply:

2.1. A ducted system supplies ventilation air directly to each bedroom and to one or more of the following rooms:

2.1.1. Living room.

2.1.2. Dining room.

2.1.3. Kitchen.

2.2. The whole-house ventilation system is a balanced ventilation system.

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R403.6 Mechanical ventilation

R403.6.1 Heat or energy recovery ventilation

Dwelling units shall be provided with a heat recovery or energy recovery ventilation system in Climate Zones 7 and 8.

The system shall be balanced with a minimum sensible heat recovery efficiency of 65 percent at 32°F at a flow greater than or equal to the design airflow.

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R403.6 Mechanical ventilation

R403.6.2 Whole-dwelling mechanical ventilation system fan efficacy

Fans used to provide whole-dwelling mechanical ventilation shall meet the efficacy requirements of Table R403.6.2 at one or more rating points. Fans shall be tested in accordance with HVI 916 and listed. The airflow shall be reported in the product listing or on the label.

Fan efficacy shall be reported in the product listing or shall be derived from the input power and airflow values reported in the product listing or on the label.

Fan efficacy for fully ducted HRV, ERC, balanced, and in-line fans shall be determined at a static pressure of not less than 0.2 inch w.c.

Fan efficacy for ducted range hoods, bathroom and utility room fans shall be determined at a static pressure of not less than 0.1 inch w.c.

TABLE R403.6.2
WHOLE-DWELLING MECHANICAL VENTILATION SYSTEM FAN EFFICACY[a]

FAN LOCATION	AIRFLOW RATE MINIMUM (CFM)	MINIMUM EFFICACY (CFM/WATT)
HRV, ERV	Any	1.2 cfm/watt
In-line supply or exhaust fan	Any	3.8 cfm/watt
Other exhaust fan	< 90	2.8 cfm/watt
Other exhaust fan	≥ 90	3.5 cfm/watt
Air-handler that is integrated to tested and *listed* HVAC equipment	Any	1.2 cfm/watt

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R403.6 Mechanical ventilation

R403.6.3 Testing

Mechanical ventilation systems shall be tested and verified to provide the minimum ventilation flow rates required by Section R403.6. Testing shall be performed according to the ventilation equipment manufacturer's instructions, or by using a flow hood or box, flow grid, or other airflow measuring device at the mechanical ventilation fan's inlet terminals or grilles, outlet terminals or grilles, or in the connected ventilation ducts. Where required by the code official, testing shall be conducted by an approved third party. A written report of the results of the test shall be signed by the party conducting the test and provided to the code official.

Exception

Kitchen range hoods that are ducted to the outside with 6-inch or larger duct and not more than one 90-degree elbow or equivalent in the duct run.

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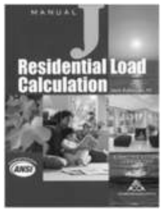
R403.7 Equipment sizing and efficiency rating

Heating and cooling equipment shall be sized in accordance with ACCA Manual S based on building loads calculated in accordance with ACCA Manual J or other approved heating and cooling calculation methodologies. New or replacement heating and cooling equipment shall have an efficiency rating equal to or greater than the minimum required by federal law for the geographic location where the equipment is installed.



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R408 Additional Efficiency Package Options

R408.2.1 Enhanced envelope performance option

The total building thermal envelope UA, the sum of U-factor times assembly area, shall be less than or equal to 95 percent of the total UA resulting from multiplying the U-factors in Table R402.1.2 by the same assembly area as in the proposed building.

The UA calculation shall be performed in accordance with Section R402.1.5. The area-weighted average SHGC of all glazed fenestration shall be less than or equal to 95 percent of the maximum glazed fenestration SHGC in Table R402.1.2.

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R408 Additional Efficiency Package Options

R408.2.2 More efficient HVAC equipment performance option

Heating and cooling equipment shall meet one of the following efficiencies:

1. Greater than or equal to 95 AFUE natural gas furnace and 16 SEER air conditioner.

2. Greater than or equal to 10 HSPF/16 SEER air source heat pump.

3. Greater than or equal to 3.5 COP ground source heat pump. For multiple cooling systems, all systems shall meet or exceed the minimum efficiency requirements in this section and shall be sized to serve 100 percent of the cooling design load. For multiple heating systems, all systems shall meet or exceed the minimum efficiency requirements in this section and shall be sized to serve 100 percent of the heating design load.

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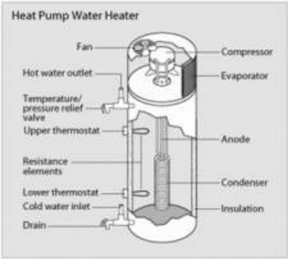
R408 Additional Efficiency Package Options

R408.2.3 Reduced energy use in service water-heating option

The hot water system shall meet one of the following efficiencies:

1. Greater than or equal to 0.82 EF fossil fuel service water-heating system.
2. Greater than or equal to 2.0 EF electric service water-heating system.
3. Greater than or equal to 0.4 solar fraction solar water-heating system.



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R408 Additional Efficiency Package Options

R408.2.4 More efficient duct thermal distribution system option

The thermal distribution system shall meet one of the following efficiencies:

1. 100 percent of ducts and air handlers located entirely within the building thermal envelope.
2. 100 percent of ductless thermal distribution system or hydronic thermal distribution system located completely inside the building thermal envelope.
3. 100 percent of duct thermal distribution system located in conditioned space as defined by Section R403.3.2.

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R408 Additional Efficiency Package Options

R408.2.5 Improved air sealing and efficient ventilation system option

The measured air leakage rate shall be less than or equal to 3.0 ACH50, with either an Energy Recovery Ventilator (ERV) or Heat Recovery Ventilator (HRV) installed. Minimum HRV and ERV requirements, measured at the lowest tested net supply airflow, shall be greater than or equal to 75 percent Sensible Recovery Efficiency (SRE), less than or equal to 1.1 cubic feet per minute per watt and shall not use recirculation as a defrost strategy. In addition, the ERV shall be greater than or equal to 50 percent Latent Recovery/Moisture Transfer (LRMT).

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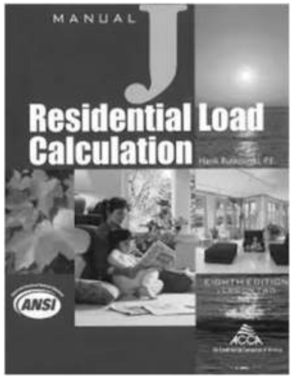

Class Outline

- Why Design?
- Load Calculation Manual J

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Why Design ?

- Oversized equipment degrades humidity control
- Oversized equipment requires larger ducts
- Oversized equipment has a higher up front cost
- Under-sizing equipment can cause discomfort during severe weather
- Oversized equipment causes short cycling and reduces the air conditioning systems ability to remove moisture

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Why Design ?

- Increased duct system efficiency
- Demonstrate “due diligence” in a court of law
- Equipment size typically 30-50% smaller than systems designed by “rule of thumb”
- Reduce operating cost
- Equipment that is sized properly operates more efficiently and economically

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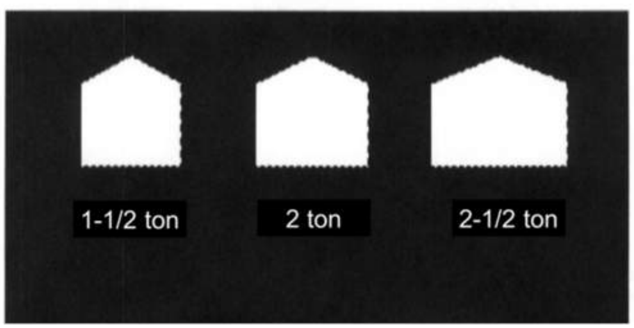

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Why Design ?

2021 IRC

M1401.3 Equipment and appliance sizing Heating and cooling *equipment* shall be sized in accordance with ACCA Manual S based on building loads calculated in accordance with ACCA Manual J or other *approved* heating and cooling calculation methodologies.

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Why Design ? **2021 IRC**

M1401.3 Exceptions

Exception: Heating and cooling equipment and appliance sizing shall not be limited to the capacities determined in accordance with Manual S where either of the following conditions applies:

1. The specified equipment or appliance utilizes multistage technology or variable refrigerant flow technology, and the loads calculated in accordance with the approved heating and cooling calculation methodology are within the range of the manufacturer's published capacities for that equipment or appliance.

2. The specified equipment or appliance manufacturer's published capacities cannot satisfy both the total and sensible heat gains calculated in accordance with the approved heating and cooling calculation methodology and the next larger standard size unit is specified.

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Why Design ? **2021 IRC**

- **M1601.1 Duct design.** *Duct systems* serving heating, cooling and *ventilation equipment* shall be fabricated in accordance with the provisions of this section and ACCA Manual D the appliance manufacturer's installation instructions_or other *approved* methods.

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2021 IRC **M1601.4.1 Joints, seams and connections**

Longitudinal and transverse joints, seams and connections in metallic and nonmetallic shall be constructed as specified in SMACNA *HVAC Duct Construction Standards-Meatal and Flexible* and NAIMA *Fibrous Glass Duct Construction Standards.* Joints, longitudinal and transverse seams, and connections in ductwork shall be securely fastened and sealed with welds, gaskets, mastics (adhesives), mastic-plus-embedded-fabric systems, liquid sealants or tapes._ …….. Closure systems used with flexible air ducts and flexible air connectors shall comply with UL 181B and shall be marked "181B-FX" for pressure-sensitive tape or "181B-M" for mastic. Closure systems used to seal all ductwork shall be installed in accordance with the manufacturer's installation instructions.

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2021 IRC **M1601.4.1 Joints, seams and connections**

Exceptions:

1. Spray polyurethane foam shall be permitted to be applied without additional joint seals.

2. Where a duct connection is made that is partially without access, three screws or rivets shall be equally spaced on the exposed portion of the joint so as to prevent a hinge effect.

3. For ducts having a static pressure classification of less than 2 inches of water column (500 Pa), additional closure systems shall not be required for continuously welded joints and seams and locking-type joints and seams. This exception shall not apply to snap-lock and button-lock type joints and seams that are located outside of conditioned spaces.

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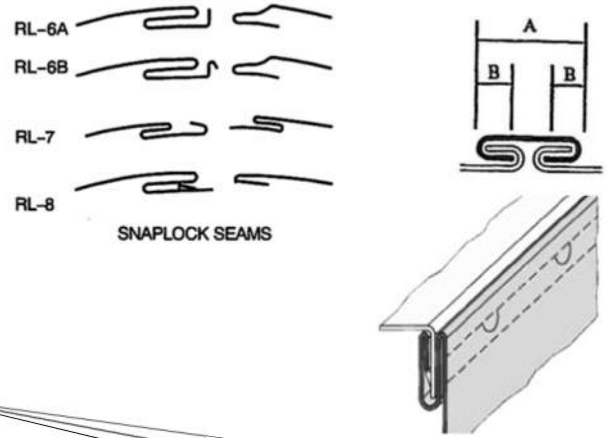


97

2021 IRC

N1103.3.4.1 (R403.3.4.1) Sealed Air Handler. Air handlers shall have a manufacturer's designation for an air leakage of no more than 2 percent of the design air flow rate when tested is accordance with ASHRAE 193.

N1103.3.5 (R403.3.5) Duct testing. Ducts shall be pressure tested in accordance with ANSI/RESNET/ICC 380 or ASTM E1554 to determine air leakage by one of the following methods

98

98

2021 IRC

1. Rough-in test: Total leakage shall be measured with a pressure differential of 0.1 inch w.g. (25 Pa) across the system, including the manufacturer's air handler enclosure if installed at the time of the test. All registers shall be taped or otherwise sealed during the test.
2. Post construction test: Total leakage shall be measured with a pressure differential of 0.1 inch w.g. (25 Pa) across the entire system, including the manufacturer's air handler enclosure. Registers shall be taped or otherwise sealed during the test.

Exception:

~~1. Duct tightness test is not required if the air handler and all ducts are located within conditioned space.~~ Montana amended to include R403.3.7

1. A duct air-leakage test shall not be required for ducts serving heat or energy recovery ventilators that are not integrated with ducts serving heating or cooling systems.

~~A written report of the results of the test shall be signed by the party conducting the test and provided to code official.~~

99

99

2021 IRC

N1103.3.6 (R403.3.6) Duct leakage The total leakage of the ducts, where measured in accordance with Section R403.3.3, shall be as follows:

1. Rough-in test: The total leakage shall be less than or equal to 4 cubic feet per minute per 100 square feet of conditioned floor area where the air handler is installed at the time of the test. Where the air handler is not installed at the time of the test, the total leakage shall be less than or equal to 3 cubic feet per minute per 100 square feet of conditioned floor area.

2. Post construction test: Total leakage shall be less than or equal to 4 cubic feet per minute per 100 square feet of conditioned floor area.

100

100

2021 IRC

3. Test for ducts within thermal envelope: Where all ducts and air handlers are located entirely within the building thermal envelope, total leakage shall be less than or equal to 8.0 cubic feet per minute per 100 square feet of conditioned floor area.

101

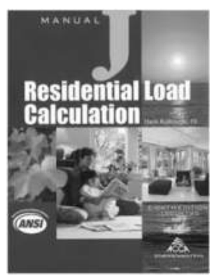
101

Why Design ?

102

The Residential HVAC Design Process:

1. Load Calculation- ACCA Manual J (8th Edition)
The entire design process leads to and rests upon the room to room load calculations. It is the Manual J that calculates the homes heating and cooling needs.
(Does the 'Code' require cooling?)



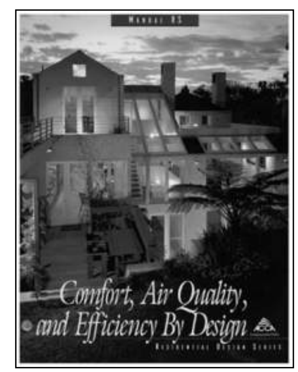
This includes each separate room's thermal requirements.
You do want each room to be comfortable, don't you??

103

The Residential HVAC Design Process:

1. Load Calculation- ACCA Manual J (8th Edition)

There are many times when more than one HVAC system is required to meet a homes heating and cooling needs.
A zoning plan would then need to be developed. **ACCA Manual RS** provides in-depth information on zoning and system selection. Zoning and system selection **MUST** be part of the homes design process.



104

The Residential HVAC Design Process:

2. Equipment Selection- ACCA Manual S
   Now that the load calculation is done, proper sized equipment can be selected. Equipment selection has its own set of rules. Learning how to read and interpret the manufactures equipment performance data including the fine print.

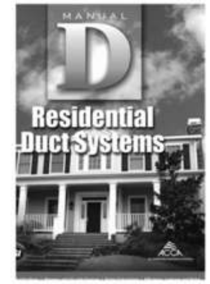
The goal here is to select equipment that will:
1. Meet the homes calculated heating and cooling needs under design conditions.
2. Will have enough blower power to move the correct amount of air through the duct system.

105

The Residential HVAC Design Process:

3. Duct Design – ACCA Manual D

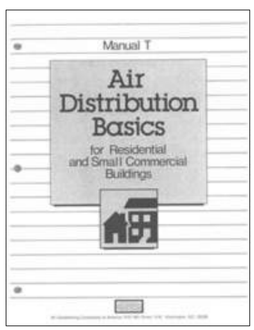
In residential systems, the duct system is designed to match the equipments blower capabilities.
<u>Not the other way around!!</u>
Careful attention must be paid to duct length and type of fittings used.
Proper attention to duct design will insure that the needed amount of conditioned air is delivered to each room.



106

The Residential HVAC Design Process:

4. Room Air Distribution – ACCA Manual T
   Selecting the proper sized grilles and registers has its own set of requirements. You could have a properly sized system, perfect equipment, an outstanding duct system and ruin everything with the incorrect grilles and registers.



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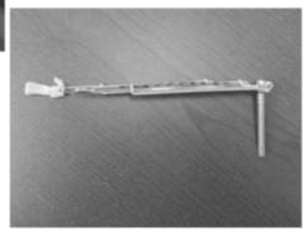
The Residential HVAC Design Process:

- Load Calculation- ACCA Manual J (8th Edition)
- Equipment Selection- ACCA Manual S
- Duct Design – ACCA Manual D
- Room Air Distribution – ACCA Manual T

108

What is needed for an accurate load calculation?



- wb = Wet Bulb
- db = Dry Bulb
- Sling psychrometer

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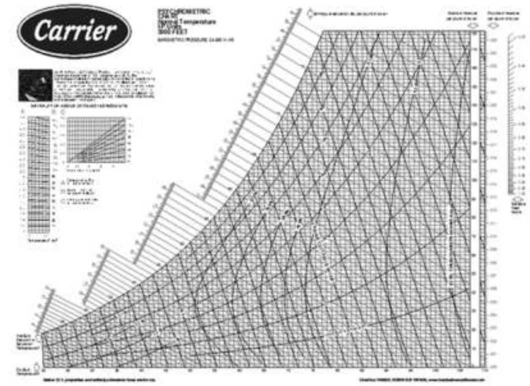


- Psychrometric Chart

110

What is needed for an accurate load calculation?

- Use outdoor design Conditions from MJ8 Table 1A

  These values are not the worst weather conditions ever experienced in a city; but they do represent extremes that on the average will only be exceeded a few dozen hours per season. Local code requirement may supersede these values.

111

What is needed for an accurate load calculation?

- 1% Summer Outdoor Drybulb, The outdoor temperature that will only be exceeded for 1% of the hours of a standard weather year, as defined by the bin hour data for that location.

112

What is needed for an accurate load calculation?

- **99% Winter Outdoor Drybulb,** The outdoor temperature that will be equal to or less than 99% of the hourly outdoor temperature that will occur during a standard weather year, as defined by the bin hour data for that location.

113

What is needed for an accurate load calculation?

Table 1A

Outdoor Design Conditions for the United States

Location	Elevation	Latitude	Winter	Summer					
	Feet	Degrees North	Heating 99% Dry Bulb	Cooling 1% Dry Bulb	Coincident Wet Bulb	Design Grains 55% RH	Design Grains 50% RH	Design Grains 45% RH	Daily Range (DR)
Helena AP	3828	46	-10	87	59	-41	-34	-28	H
Kalispell AP	6780	48	-3	86	61	-29	-22	-16	H
Lewiston AP	4122	47	-12	86	60	-34	-27	-21	H

- Coincident Wet Bulb represents the average wet-bulb temperature expected to co-exist with the 1% dry-bulb temperature
- From https://ashrae-meteo.info/v2.0/

HELENA, MT, USA (WMO: 727720)

Lat 46.606N Long 111.964W Elev 3828 StdP: 12.77 Time zone -7.00 (NAM) Period 94-19 WBAN 24144 Climate zone 6B

Annual Heating, Humidification, and Ventilation Design Conditions

Coldest Month	Heating DB		Humidification DP/MCDB and HR						Coldest month WS/MCDB				MCWS/PCWD to 99.6% DB		WSF
			99.6%			99%			0.4%		1%				
	99.6%	99%	DP	HR	MCDB	DP	HR	MCDB	WS	MCDB	WS	MCDB	MCWS	PCWD	
1	-10.6	-5.3	-18.2	2.3	-9.6	-12.3	3.3	-4.8	27.3	40.3	24.4	40.1	3.6	280	0.612

Annual Cooling, Dehumidification, and Enthalpy Design Conditions

Hottest Month	Hottest Month DB Range	Cooling DB/MCWB						Evaporation WB/MCDB						MCWS/PCWD to 0.4% DB	
		0.4%		1%		2%		0.4%		1%		2%			
		DB	MCWB	DB	MCWB	DB	MCWB	WB	MCDB	WB	MCDB	WB	MCDB	MCWS	PCWD
7	29.7	93.4	61.5	90.1	60.7	86.8	59.8	64.4	85.5	62.8	83.8	61.4	81.8	10.0	290

114

What is needed for an accurate load calculation?

- Indoor design conditions
- Winter
  70° Dry Bulb at a RH that will not produce visible condensation. This is typically not more than 30%.
- Summer
  75° Dry Bulb at 50% RH This is psychrometrically equivalent to 62° wet bulb. This will be important when we size the cooling equipment.

115

What is needed for an accurate load calculation?

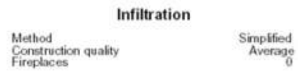
- Infiltration Estimates
  Full credit should be taken for the type of construction used. This could be from blower door tests or builders track record.

116

What is needed for an accurate load calculation?

- MJ8 has five construction types:

	ACH Heating	Cooling
Tight ----------	.10	.05
Semi-Tight --	.19	.10
Average ------	.28	.15
Semi-Loose --	.43	.23
Loose ---------	.58	.30



- Typically, builders will use 'Average' construction.

117

What is needed for an accurate load calculation?

- Solar Loads Associated with Glass

In MJ8 solar gains are ignored in the heating calculation. This produces a conservative estimate of the load associated with an extended period of heavy day time cloud cover.

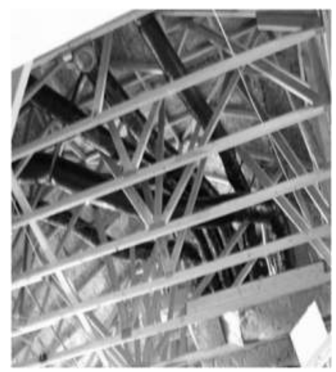
118

What is needed for an accurate load calculation?

- Solar Loads Associated with Glass
- In the case of the MJ8 cooling load, the tabulated data provides an estimate of the combined load (solar and conductance) associated with the glass, by direction of exposure. Be sure and take credit for drapes, insect screens, blinds, external screens and overhangs.

119

What is needed for an accurate load calculation?



- Duct losses and Gains

Where and how ducts are installed can have a large impact on the required loads. Ducts installed in an attic can add a ton or more to the air conditioning load.

Leaky ductwork can range from 30% to more than 45% of the blower CFM.

120

What is needed for an accurate load calculation?

- Conduction Loads
  The structural component conduction loads caused by the design conditions can be reasonably calculated.
  The designer should take full credit for all construction details. R-values, mass walls, etc.

121

What is needed for an accurate load calculation?

- Ventilation Loads
  Some builders may choose to bring in ventilation air or may be required by the local code.
  How the ventilation air is introduced into the system will determine the effect on heating or air conditioning loads. Is the air brought directly into the return air trunk line or through a heat-recovery devise?

122

What is needed for an accurate load calculation?

- Internal loads
  MJ8 provides some generic values for internal loads created by people and appliances. Defaults for MJ8:
  Appliances – 1500 Btuh per appliance
  People – 230 Btuh Sensible, 200 Btuh Latent, 20 cfm of ventilation air per person

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Load Calculation- ACCA Manual J (8th Edition)

There are seven approved ACCA Manual J 8th Edition software programs

- Elite Software RHVAC
- Wrightsoft Right-J8
- Adtek AccuLoads
- Florida Solar Energy Center's EnergyGauge
- Carmelsoft HVAC ResLoad-J
- Avenir MJ8 Editions of HeatCAD and LoopCAD
- Cool Calc Manual J

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Load Calculation- ACCA Manual J-AE

Manual J-AE (Abridged Edition) has limitations:

- The structure is a single family detached dwelling; the total window, glass door and skylight area does not exceed 15% of the associated floor area.
- The glass is equitably distributed around all sides of the dwelling – the dwelling appears to have obvious and sufficient exposure diversity.
- Heating and cooling is provided by a central, single zone, constant volume system.
- The comfort system is not equipped with a ventilation heat exchanger or a ventilating dehumidifier.

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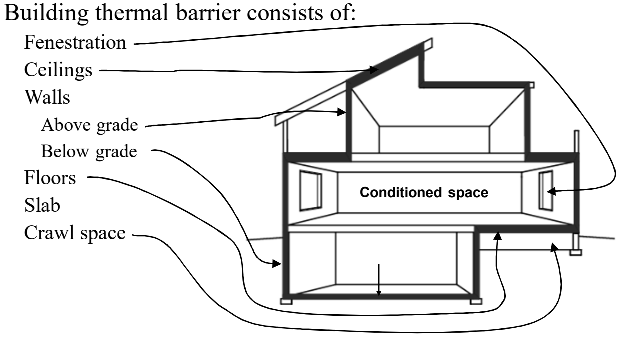
Load Calculation- ACCA Manual J-AE

- These are the first four of twenty-six different requirements that must be answered with a ‘Yes’ to confirm that MJ-AE is the appropriate calculation tool.
- MJ-AE is very good for learning the basic requirements for residential load calculation.

126

DEFINE THE BUILDING THERMAL BARRIER

Building thermal barrier consists of:



127

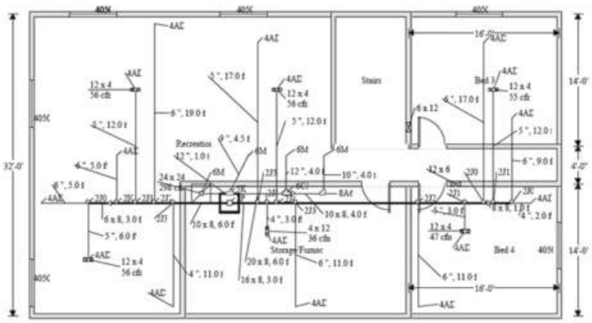
Today's House
(Denver at 5333')
Climate Zone 5B

- R-21 Exterior Wal
- R-50 Ceilings
- R-30 Floors
- Windows –

U-Value = .32
SHGC = .40

128

Today's House



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DESIGN LOADS

Weather Data from ASHRAE / Table 1A

- 1% Summer Outdoor Drybulb = 90° F
- 99% Winter Outdoor Drybulb = -3° F
- Elevation = 5333'

130

Weather: Denver, CO, US

Winter Design Conditions

Outside db	-3	°F
Inside db	70	°F
Design TD	73	°F

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Summer Design Conditions

Outside db	90	°F
Inside db	75	°F
Design TD	15	°F
Daily range	H	
Relative humidity	50	%
Moisture difference	-36	gr/lb

Daily Range is the average difference between the daily high and low dry bulb temperatures at a particular location.
Low (L) = swing less than 16° F
Medium (M) = swing between 16° F and 25° F
High (H) = swing exceeds 25° F

Moisture Difference is the absolute humidity differential between the outdoor air and the indoor air, expressed in grains of water per pound of air.

132

Design conditions must be correct

Weather: Denver, CO, US

Winter Design Conditions		
Outside db	-3	°F
Inside db	70	°F
Design TD	73	°F

Summer Design Conditions		
Outside db	90	°F
Inside db	75	°F
Design TD	15	°F
Daily range	H	
Relative humidity	50	%
Moisture difference	-36	gr/lb

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DESIGN LOADS

Ducts with no load would be located entirely inside the buildings thermal barrier.
Central vent is the result of ventilation air.

Heating Summary		
Structure	28273	Btuh
Ducts	0	Btuh
Central vent (64 cfm)	4213	Btuh
Humidification	0	Btuh
Piping	0	Btuh
Equipment load	32486	Btuh

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DESIGN LOADS

This value is used to calculate the occupant ventilation requirement, which is used to calculate the Central Supply Ventilation AVF. You may need to override this value to comply with local building codes. Manual J8 calculates the central ventilation load as the outdoor air requirement less the summer infiltration AFV. The outdoor air requirement is calculated as the largest of 3 values:

Heating Summary		
Structure	28273	Btuh
Ducts	0	Btuh
Central vent (64 cfm)	4213	Btuh
Humidification	0	Btuh
Piping	0	Btuh
Equipment load	32486	Btuh

Solve for today's house
1. .35 x 14,464/60 = 84
2. 20 x 5 = 100
3. 0.50 x 40,000 / 1000 = 20

100 cfm - 36 cfm = 64 cfm

1. General ventilation 0.35 x above grade volume of conditioned space/ 60
2. Occupant ventilation Minimum ventilation per person x Number of occupants
3. Combustion air requirements 0.50 x input capacity of furnace with atmospheric burner/1000

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DESIGN LOADS

Infiltration		
Method		Simplified
Construction quality		Average
Fireplaces		0
	Heating	**Cooling**
Area (ft²)	3600	3600
Volume (ft³)	14464	14464
Air changes/hour	0.28	0.15
Equiv. AVF (cfm)	67	36

Volume is the above grade volume

Air changes /hour for heating is done with a 15 mph wind and 7.5 mph for cooling

AVF = Air Volume Flow

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DESIGN LOADS

Sensible Load

The heat gain of the home due to conduction, solar radiation, infiltration, appliances, people and pets. Burning a light bulb, for example, adds only sensible load to the house. The sensible load raises the dry-bulb temperature.

Sensible Cooling Equipment Load Sizing

Structure	14954	Btuh
Ducts	0	Btuh
Central vent (64 cfm)	877	Btuh
Blower	0	Btuh
Use manufacturer's data	y	
Rate/swing multiplier	1.00	
Equipment sensible load	15832	Btuh

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DESIGN LOADS

Latent Cooling Load

The net amount of moisture added to the inside air by people, plants, cooking, infiltration and any other moisture source.

SHR = Sensible Heat Ratio

The ratio of sensible load to total load

Example House

15,832/ 15,832 = 1.00

So why are we using .85 ???

Latent Cooling Equipment Load Sizing

Structure	274	Btuh
Ducts	0	Btuh
Central vent (64 cfm)	-1281	Btuh
Equipment latent load	0	Btuh
Equipment total load	15832	Btuh
Req. total capacity at 0.85 SHR	1.6	ton

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Sensible Heat Equation to calculate a preliminary cooling CFM

CFM = Sensible Load / (1.1 x ACF x ΔT)

Where:

- Sensible Load (Btuh) is the sensible cooling load from the MJ8 load calculation.
- CFM (cubic feet per minute) is the volume of the air moving through the furnace and the indoor cooling coil.
- 1.1 is a physical constant for the equation.
- ACF (altitude correction factor) is the adjustment for air density at the local altitude.
- ΔT is the temperature difference in the air between the inlet and the outlet furnace/cooling coil. We will use the table from Manual S.
- A high SHR will have a low or negative latent load (like Denver)
- A low SHR will have a large latent load (like Florida)
- Math for Today CFM= 15,832/(1.1 x .832 x 17) = 1,017 cfm

Sensible Heat Ratio vs. Cooling Coil Temperature Difference (ΔT)	
JSHR	ΔT
Below 0.80	21° F
0.80 – 0.85	19° F
Above 0.85	17° F
ΔT = Entering Dry Bulb – Leaving Dry Bulb	

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DESIGN LOADS

Design Information

Weather: Denver, CO, US

Winter Design Conditions

Outside db	-3	°F
Inside db	70	°F
Design TD	73	°F

Summer Design Conditions

Outside db	90	°F
Inside db	75	°F
Design TD	15	°F
Daily range	H	
Relative humidity	50	%
Moisture difference	-36	gr/lb

Heating Summary

Structure	26853	Btuh
Ducts	0	Btuh
Central vent (64 cfm)	4213	Btuh
Humidification	0	Btuh
Piping	0	Btuh
Equipment load	31066	Btuh

Infiltration

Method		Simplified
Construction quality		Average
Fireplaces		0
	Heating	Cooling
Area (ft²)	3600	3600
Volume (ft³)	14464	14464
Air changes/hour	0.28	0.15
Equiv. AVF (cfm)	67	36

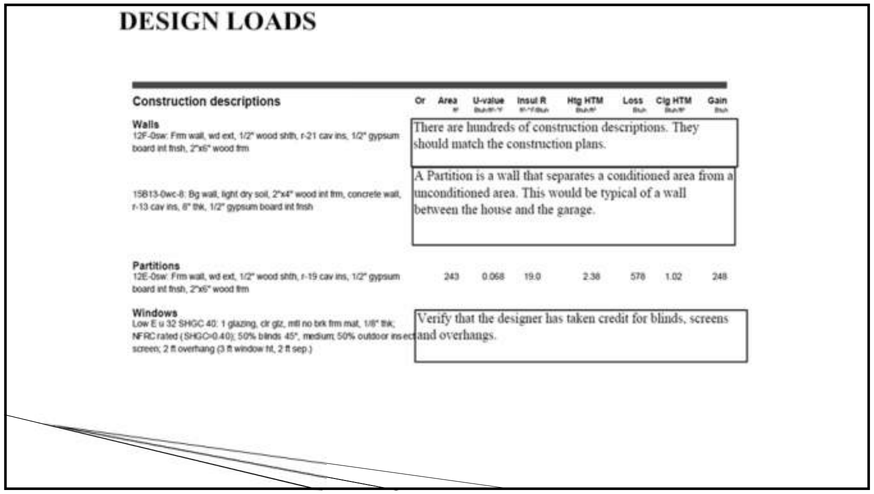
Sensible Cooling Equipment Load Sizing

Structure	14954	Btuh
Ducts	0	Btuh
Central vent (64 cfm)	877	Btuh
Blower	0	Btuh
Use manufacturer's data	y	
Rate/swing multiplier	1.00	
Equipment sensible load	15832	Btuh

Latent Cooling Equipment Load Sizing

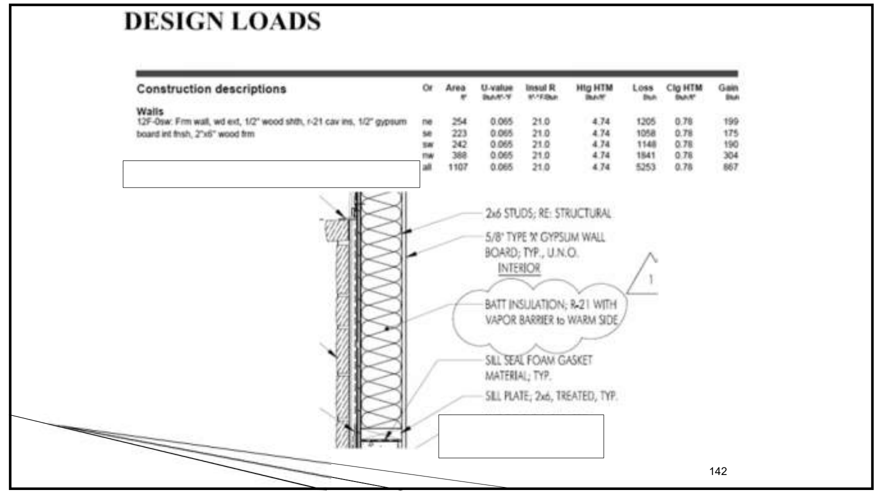
Structure	274	Btuh
Ducts	0	Btuh
Central vent (64 cfm)	-1281	Btuh
Equipment latent load	0	Btuh
Equipment total load	15832	Btuh
Req. total capacity at 0.85 SHR	1.6	ton

140



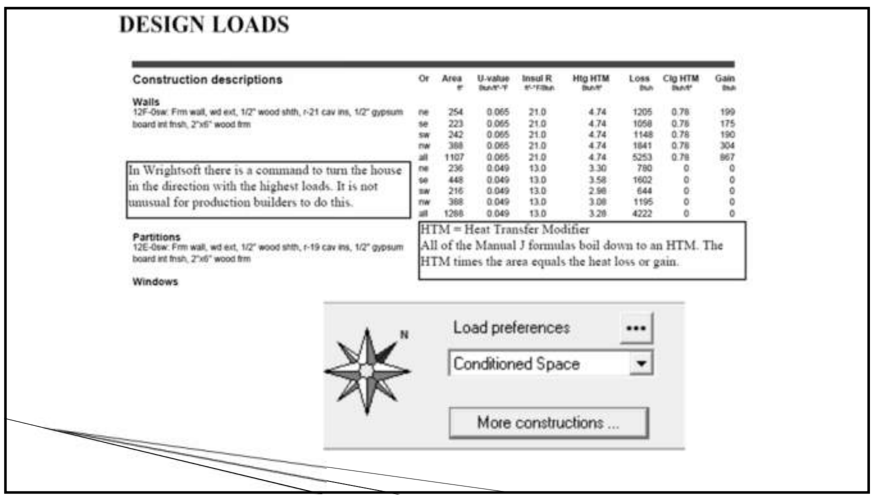
Construction descriptions	Or	Area	U-value	Insul R	Htg HTM	Loss	Clg HTM	Gain
Partitions: 12E-0sw: Frm wall, wd ext, 1/2" wood shth, r-19 cav ins, 1/2" gypsum board int fnsh, 2"x6" wood frm		243	0.068	19.0	2.38	578	1.02	248

141



Construction descriptions	Or	Area	U-value	Insul R	Htg HTM	Loss	Clg HTM	Gain
Walls: 12F-0sw: Frm wall, wd ext, 1/2" wood shth, r-21 cav ins, 1/2" gypsum board int fnsh, 2"x6" wood frm	ne	254	0.065	21.0	4.74	1205	0.78	199
	se	223	0.065	21.0	4.74	1058	0.78	175
	sw	242	0.065	21.0	4.74	1148	0.78	190
	nw	388	0.065	21.0	4.74	1841	0.78	304
	all	1107	0.065	21.0	4.74	5253	0.78	867

142



Construction descriptions	Or	Area	U-value	Insul R	Htg HTM	Loss	Clg HTM	Gain
Walls: 12F-0sw: Frm wall, wd ext, 1/2" wood shth, r-21 cav ins, 1/2" gypsum board int fnsh, 2"x6" wood frm	ne	254	0.065	21.0	4.74	1205	0.78	199
	se	223	0.065	21.0	4.74	1058	0.78	175
	sw	242	0.065	21.0	4.74	1148	0.78	190
	nw	388	0.065	21.0	4.74	1841	0.78	304
	all	1107	0.065	21.0	4.74	5253	0.78	867
	ne	236	0.049	13.0	3.30	780	0	0
	se	448	0.049	13.0	3.58	1602	0	0
	sw	216	0.049	13.0	2.98	644	0	0
	nw	388	0.049	13.0	3.08	1195	0	0
	all	1288	0.049	13.0	3.28	4222	0	0
Partitions: 12E-0sw: Frm wall, wd ext, 1/2" wood shth, r-19 cav ins, 1/2" gypsum board int fnsh, 2"x6" wood frm								

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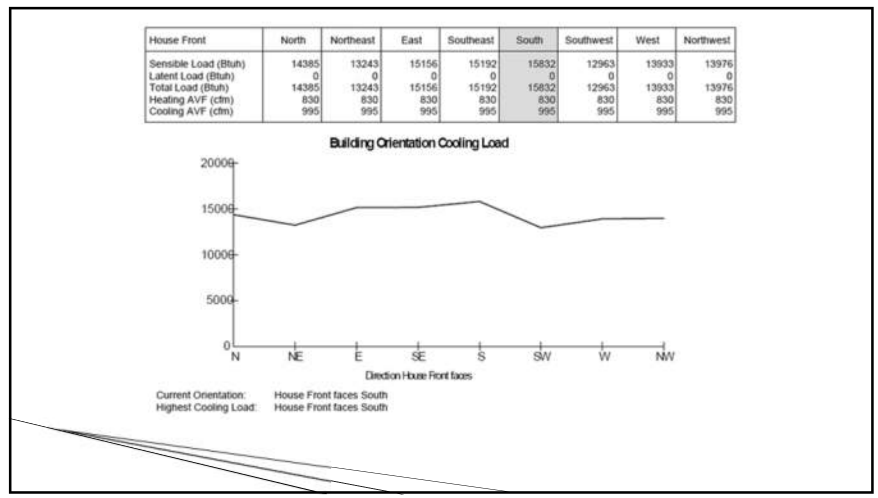

House Front	North	Northeast	East	Southeast	South	Southwest	West	Northwest
Sensible Load (Btuh)	14385	13243	15156	15192	15832	12963	13933	13976
Latent Load (Btuh)	0	0	0	0	0	0	0	0
Total Load (Btuh)	14385	13243	15156	15192	15832	12963	13933	13976
Heating AVF (cfm)	830	830	830	830	830	830	830	830
Cooling AVF (cfm)	995	995	995	995	995	995	995	995

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DESIGN LOADS

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DESIGN LOADS

6	c) AED excursion						1812				523
	Envelope loss/gain					22399	10906			3450	2236
12	a) Infiltration b) Room ventilation					4454 0	497 0			1177 0	131 0
13	Internal gains:	Occupants @ Appliances/other	230	5			1150 2400	0			0 0
	Subtotal (lines 6 to 13)					26853	14954			4627	2367
   14 15	**Less external load** **Less transfer** **Redistribution** Subtotal Duct loads			0%	0%	0 0 0 26853 0	0 0 0 14954 0	-0%	0%	0 0 231 4858 0	0 0 70 2437 0
	Total room load **Air required (cfm)**					26853 830	14954 995			4858 150	2437 162

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DESIGN LOADS

- Adequate Exposure Diversity
  According to Manual J 8 procedures, a zone is defined as having Adequate Exposure Diversity (AED) if the maximum hourly glazing load (PFG) does not exceed the average glazing load (AFG) by more than 30%. The amount over 30% of the AFG is defined as the AED Excursion.

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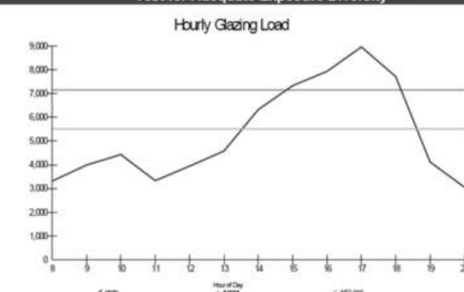
DESIGN LOADS

Test for Adequate Exposure Diversity



Maximum hourly glazing load exceeds average by 63.0%.

House does not have adequate exposure diversity (AED), based on AED limit of 30%.

AED excursion: 1812 Btuh (PFG - 1.3*AFG)

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DESIGN LOADS

- Questions on design loads ?

wrightsoft Project Summary
Entire House
Gil Rossmiller

Job:
Date:
By: Gil Rossmiller

Project Information

For: Colorado ED Inst. March 2012

Notes:

Design Information

Weather: Denver, CO, US

Winter Design Conditions

Outside db	-3	°F
Inside db	70	°F
Design TD	73	°F

Summer Design Conditions

Outside db	90	°F
Inside db	75	°F
Design TD	15	°F
Daily range	H	
Relative humidity	50	%
Moisture difference	-36	gr/lb

Heating Summary

Structure	26853	Btuh
Ducts	0	Btuh
Central vent (64 cfm)	4213	Btuh
Humidification	0	Btuh
Piping	0	Btuh
Equipment load	31066	Btuh

Sensible Cooling Equipment Load Sizing

Structure	14954	Btuh
Ducts	0	Btuh
Central vent (64 cfm)	877	Btuh
Blower	0	Btuh
Use manufacturer's data	y	
Rate/swing multiplier	1.00	
Equipment sensible load	15832	Btuh

Infiltration

Method	Simplified	
Construction quality	Average	
Fireplaces	0	

	Heating	Cooling
Area (ft²)	3600	3600
Volume (ft³)	14464	14464
Air changes/hour	0.28	0.15
Equiv. AVF (cfm)	67	36

Latent Cooling Equipment Load Sizing

Structure	274	Btuh
Ducts	0	Btuh
Central vent (64 cfm)	-1281	Btuh
Equipment latent load	0	Btuh
Equipment total load	15832	Btuh
Req. total capacity at 0.85 SHR	1.6	ton

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Copyright Materials

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