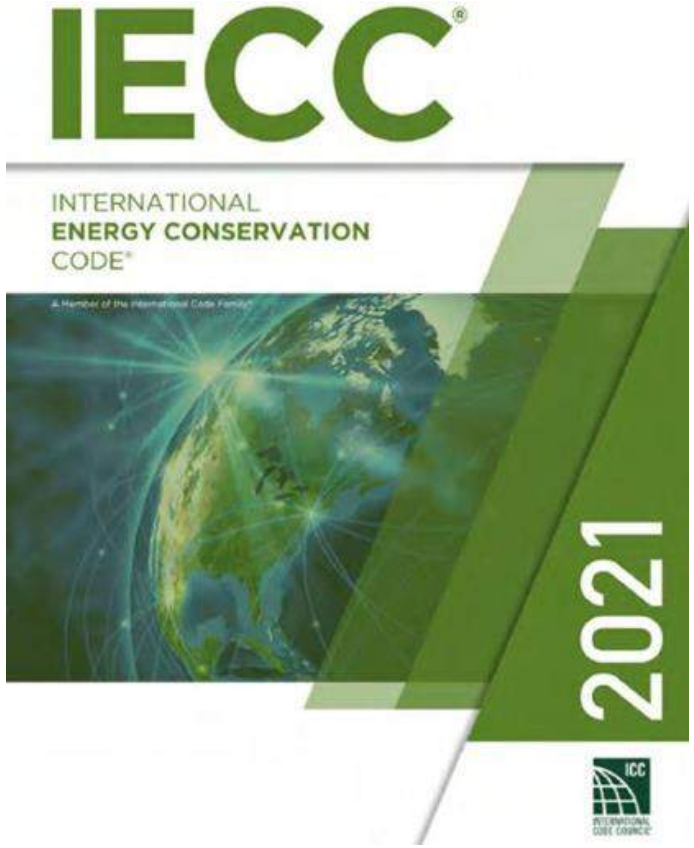
Residential Energy Submittal Information



Residential Energy Submittal Information

 1

1

Instructor
Gil Rossmiller

Over 40 years in the construction industry

IRC Plumbing & Mechanical Code Development Committee 2009-2012

Commercial Energy Code Development Committee 2015-2018

Residential Energy Code Development Committee 2021-2024

2003 – 2016
Building Official
Parker, Colorado

 2

2

Definitions

ABOVE-GRADE WALL

A wall more than 50 percent above grade and enclosing conditioned space. This includes between-floor spandrels, peripheral edges of floors, roof and basement knee walls, dormer walls, gable end walls, walls enclosing a mansard roof and skylight shafts

 3

3

Definitions

AIR BARRIER

One or more materials joined together in a continuous manner to restrict or prevent the passage of air through the building thermal envelope and its assemblies.

 4

4

Definitions

BUILDING THERMAL ENVELOPE

The basement walls, exterior walls, floors, ceiling, roofs and any other building element assemblies that enclose conditioned space or provide a boundary between conditioned space and exempt or unconditioned space

 5

5

Definitions

FENESTRATION. Products classified as either vertical fenestration or skylights.

Skylights

Glass or other transparent or translucent glazing material installed at a slope of less than 60 degrees from horizontal including unit skylights, tubular daylighting devices, and glazing materials in solariums, sunrooms, roofs and sloped walls.

Vertical fenestration

Windows that are fixed or operable, opaque doors, glazed doors, glazed block and combination opaque/glazed doors composed of glass or other transparent or translucent glazing materials and installed at a slope of not less than 60 degrees from horizontal.

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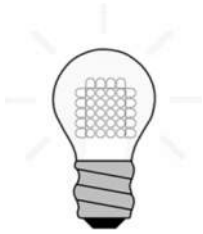
Definitions

HIGH-EFFICACY LIGHT SOURCES

Any lamp with an efficacy of not less than 65 lumens per watt, or luminaires with an efficacy of not less than 45 lumens per watt.



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Definitions

DWELLING UNIT ENCLOSURE AREA

The sum of the area of ceiling, floors, and walls separating a dwelling unit's conditioned space from the exterior or from adjacent conditioned or unconditioned spaces. Wall height shall be measured from the finished floor of the dwelling unit to the underside of the floor above.

 8

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Definitions

CAVITY INSULATION

Insulating material located between framing members

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Definitions

CONTINUOUS INSULATION (ci)

Insulating material that is continuous across all structural members without thermal bridges other than fasteners and service openings. It is installed on the interior or exterior, or is integral to any opaque surface, of the building envelope.

 10

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Definitions

SUNROOM

A one-story structure attached to a dwelling with a glazing area in excess of 40 percent of the gross area of the structure's exterior walls and roof.

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Definitions

RESIDENTIAL BUILDING

For this code, includes detached one- and two-family dwellings and townhouses as well as Group R-2, R-3 and R-4 buildings three stories or less in height above grade plane.

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12

R103.2 Information on construction documents

Construction documents shall be drawn to scale on suitable material. Electronic media documents are permitted to be submitted where approved by the code official. Construction documents shall be of sufficient clarity to indicate the location, nature and extent of the work proposed, and show in sufficient detail pertinent data and features of the building, systems and equipment as herein governed. Details shall include the following as applicable:

1. Energy compliance path.
2. Insulation materials and their R-values.
3. Fenestration U-factors and solar heat gain coefficients (SHGC).
4. Area-weighted U-factor and solar heat gain coefficients (SHGC) calculations.
5. Mechanical system design criteria.
6. Mechanical and service water-heating systems and equipment types, sizes and efficiencies.
7. Equipment and system controls.
8. Duct sealing, duct and pipe insulation and location.
9. Air sealing details

 13

13

1. Energy compliance path

CODE ENFORCEMENT:
- 2021 INTERNATIONAL BUILDING CODE
- 2021 INTERNATIONAL ENERGY CONSERVATION CODE
- 2021 INTERNATIONAL EXISTING BUILDING CODE
- 2021 INTERNATIONAL FIRE CODE
- 2021 INTERNATIONAL FUEL GAS CODE
- 2021 INTERNATIONAL MECHANICAL CODE
- 2021 INTERNATIONAL PLUMBING CODE
- 2021 INTERNATIONAL RESIDENTIAL CODE
- 2021 NATIONAL GREEN BUILDING STANDARDS
- 2023 NATIONAL ELECTRICAL CODE

ENERGY COMPLIANCE: PRESCRIPTIVE PATH

R401.2.1 Prescriptive Compliance Option

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

R402.1.2 Insulation and fenestration criteria

(U-factor table)

R402.1.3 R-value alternative (R-value table)

R402.1.4 R-value computation

R402.1.5 Total UA alternative (REScheck)

 14

14

R402.1.3 R-value alternative (R-value table)

Insulation: Provide a Fully Insulated Building Thermal Envelope As Follows:

FENESTRATION U-FACTOR [b]	SKYLIGHT U-FACTOR [b]	GLAZED FENESTRATION SHGC [b,e]	CEILING R-VALUE	WOOD FRAME WALL R-VALUE [i]	MASS WALL R-VALUE [k]	FLOOR R-VALUE	BASEMENT WALL R-VALUE [c,i]	SLAB R-VALUE AND DEPTH [c,i]	CRAWL SPACE WALL R-VALUE [c,i]
0.30	0.55	.40	60	30R OR 20+5 or 13 +10ci	13/17	30	15ci or 19 or 13+5ci	10ci, 4 FT.	15ci or 19 or 13+5ci

For SI: 1 foot = 304.8 mm.
NR = Not Required.
ci = continuous insulation.

a. R-values are minimums. U-factors and SHGC are maximums. Where insulation is installed in a cavity that is less than the label or design thickness of the insulation, the installed R-value of the insulation shall be not less than the R-value specified in the table.
b. The fenestration U-factor column excludes skylights. The SHGC column applies to all glazed fenestration.
c. Exception: In Climate Zones 0 through 3, skylights shall be permitted to be excluded from glazed fenestration SHGC requirements provided that the SHGC for such skylights does not exceed 0.30.
d. "5ci or 13" means R-5 continuous insulation (ci) on the interior or exterior surface of the wall or R-13 cavity insulation on the interior side of the wall. "10ci or 13" means R-10 continuous insulation (ci) on the interior or exterior surface of the wall or R-13 cavity insulation on the interior side of the wall. "15ci or 19 or 13 + 5ci" means R-15 continuous insulation (ci) on the interior or exterior surface of the wall; or R-19 cavity insulation on the interior side of the wall; or R-13 cavity insulation on the interior of the wall in addition to R-5 continuous insulation on the interior or exterior surface of the wall.
e. R-5 insulation shall be provided under the full slab area of a heated slab in addition to the required slab edge insulation R-value for slabs, as indicated in the table. The slab-edge insulation for heated slabs shall not be required to extend below the slab.
f. There are no SHGC requirements in the Marine Zone.
g. Basement wall insulation shall not be required in Warm Humid locations as defined by Figure N1101.7 and Table N1101.7.
h. The first value is cavity insulation; the second value is continuous insulation. Therefore, as an example, "13 + 5" means R-13 cavity insulation plus R-5 continuous insulation.
i. Mass walls shall be in accordance with Section N1102.2.5. The second R-value applies where more than half of the insulation is on the interior of the mass wall.
j. A maximum U-factor of 0.32 shall apply in Climate Zones 3 through 8 to vertical fenestration products installed in buildings located either:
   1. Above 4,000 feet in elevation, or
   2. In windborne debris regions where protection of openings is required by Section R301.2.1.2.

 15

15

R402.1.5 Total UA alternative (REScheck)

Compliance: Passes using UA trade-off

Compliance: **0.0% Better Than Code** Maximum UA: **270** Your UA: **270**

The % Better or Worse Than Code Index reflects how close to compliance the house is based on code trade-off rules.
It DOES NOT provide an estimate of energy use or cost relative to a minimum-code home.

Slab-on-grade tradeoffs are no longer considered in the UA or performance compliance path in REScheck. Each slab-on-grade assembly in the specified climate zone must meet the minimum energy code insulation R-value and depth requirements.

Envelope Assemblies

Assembly	Gross Area or Perimeter	Cavity R-Value	Cont. R-Value	Prop. U-Factor	Req. U-Factor	Prop. UA	Req. UA
Ceiling: Flat Ceiling or Scissor Truss	1,500	60.0	0.0	0.024	0.024	36	36
Wall: Wood Frame, 16" o.c.	1,440	26.0	0.0	0.052	0.045	60	52
Door: Glass Door (over 50% glazing)	42			0.320	0.320	13	13
Window 2: Vinyl Frame	250			0.320	0.320	80	80
Basement Wall: Solid Concrete or Masonry Wall height: 8.0' Depth below grade: 7.5' Insulation depth: 8.0'	1,440	0.0	15.0	0.044	0.050	61	69
Window: Vinyl Frame	64			0.320	0.320	20	20

 16

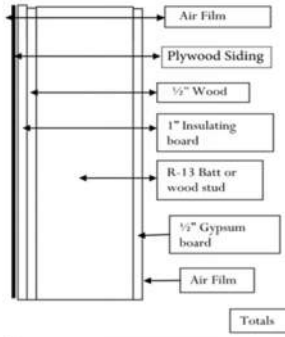
16

R402.1.2 Insulation and fenestration criteria

CLIMATE ZONE	FENESTRATION *U*-FACTOR[f]	SKYLIGHT *U*-FACTOR	GLAZED FENESTRATION SHGC[d, e]	CEILING *U*-FACTOR	WOOD FRAME WALL *U*-FACTOR	MASS WALL *U*-FACTOR[b]	FLOOR *U*-FACTOR	BASEMENT WALL *U*-FACTOR	CRAWL SPACE WALL *U*-FACTOR
0	0.50	0.75	0.25	0.035	0.084	0.197	0.064	0.360	0.477
1	0.50	0.75	0.25	0.035	0.084	0.197	0.064	0.360	0.477
2	0.40	0.65	0.25	0.026	0.084	0.165	0.064	0.360	0.477
3	0.30	0.55	0.25	0.026	0.060	0.098	0.047	0.091[c]	0.136
4 except Marine	0.30	0.55	0.40	0.024	0.045	0.098	0.047	0.059	0.065
5 and Marine 4	0.30	0.55	0.40	0.024	0.045	0.082	0.033	0.050	0.055
6	0.30	0.55	NR	0.024	0.045	0.060	0.033	0.050	0.055
7 and 8	0.30	0.55	NR	0.024	0.045	0.057	0.028	0.050	0.055

17

R402.1.2 Insulation and fenestration criteria



	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)

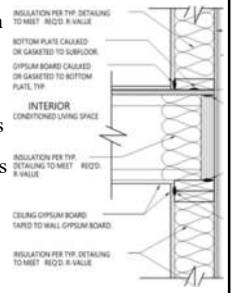
Average R= (0.80 x 19.27) + (0.20 x 10.82) = 15.41 + 2.16 = 17.57

U-value = 1/17.57 = 0.057

18

R402.1.4 R-value computation

Cavity insulation alone shall be used to determine compliance with the cavity insulation R-value requirements in Table R402.1.3. Where cavity insulation is installed in multiple layers, the R-values of the cavity insulation layers shall be summed to determine compliance with the cavity insulation R-value requirements. The manufacturer's settled R-value shall be used for blown-in insulation. Continuous insulation (ci) alone shall be used to determine compliance with the continuous insulation R-value requirements in Table R402.1.3. Where continuous insulation is installed in multiple layers, the R-values of the continuous insulation layers shall be summed to determine compliance with the continuous insulation R-value requirements. Cavity insulation R-values shall not be used to determine compliance with the continuous insulation R-value requirements in Table R402.1.3. Computed R-values shall not include an R-value for other building materials or air films. Where insulated siding is used for the purpose of complying with the continuous insulation requirements of Table R402.1.3, the manufacturer's labeled R-value for the insulated siding shall be reduced by R-0.6



19

R405.2 Performance-based compliance

IECC COMPLIANCE METHOD:
SIMULATED PERFORMANCE PATH ALTERNATIVE (HERS)

IECC 2021 Performance Compliance

Property	Organization	Inspection Status
		Results are projected

This report is based on a proposed design and does not confirm field enforcement of design elements.

Annual Energy Cost

Design	IECC 2021 Performance	As Designed
Heating	$376	$326
Cooling	$98	$124
Water Heating	$152	$152
Mechanical Ventilation	$42	$11
SubTotal - Used to determine compliance	**$668**	**$613**
Lights & Appliances w/out Ventilation	$650	$650
Onsite generation	$0	$0
Total	**$1,318**	**$1,263**

R405.3 Source Energy Exception: The proposed home uses 6.75 MBtu LESS source energy than the reference home.

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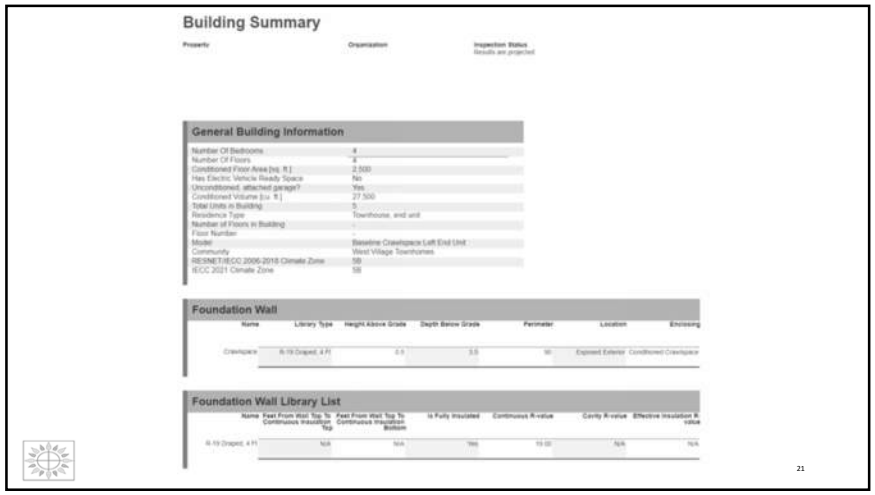

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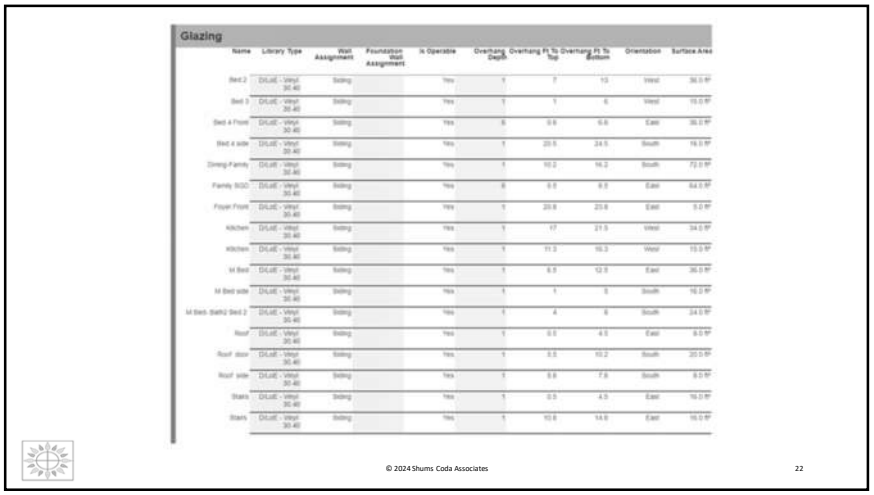

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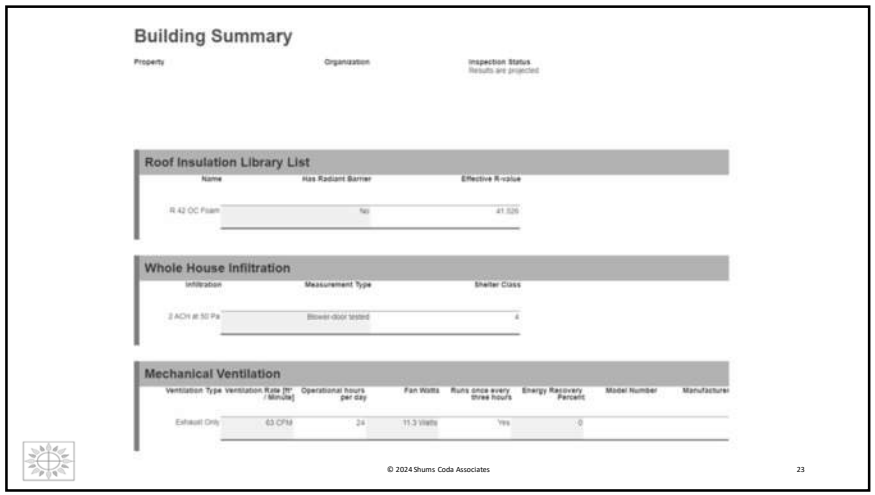

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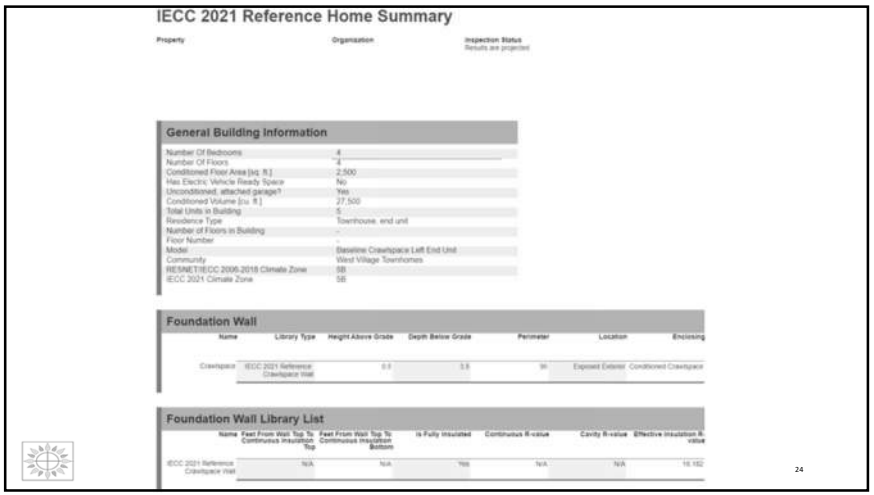

24

2018 IECC R-406 Projected Energy Rating Index Report

Property
Builder:Best Builder In America Homes
Address:
8925 Place to live, Denver, CO 80238

Organization
Company:EnergyLogic
Phone:720-838-0677
Rater:Robby Schwarz

Energy Rating Index Information
Projected Rating
Rating No:
Rater ID (RTIN):9124083
Date Rated:2016-09-29

Estimated Annual Energy Consumption*

	Rated Home Calculated Energy Use (MBtu)	Rated Home Cost ($/yr)
Heating	48.8	$476
Cooling	1.8	$63
Water Heating	10.2	$97
Lights & Appliances	22.1	$703
Photovoltaics	0.0	$0
Total	82.9	$1,339

*Based on standard operating conditions

ERI with PV:61

ERI without PV:61

Annual Estimates

Electric (kWh):6,202.5	CO2 Emissions (Tons):9.6
Natural Gas (Therms):617.0	

Maximum Energy Rating Index:61 | This Home's Energy Rating Index:61 | PASS

This home MEETS the Energy Rating Index Score requirement of 2018 IECC R-406 for Climate Zone 5. It MEETS all of the requirements verified by Ekotrope. Mandatory requirements are summarized on the 2nd page of this report, some of which are not verified by Ekotrope.

Name: Robby Schwarz Signature:

Organization: EnergyLogic Date: 11/26/19 at 2:21 PM

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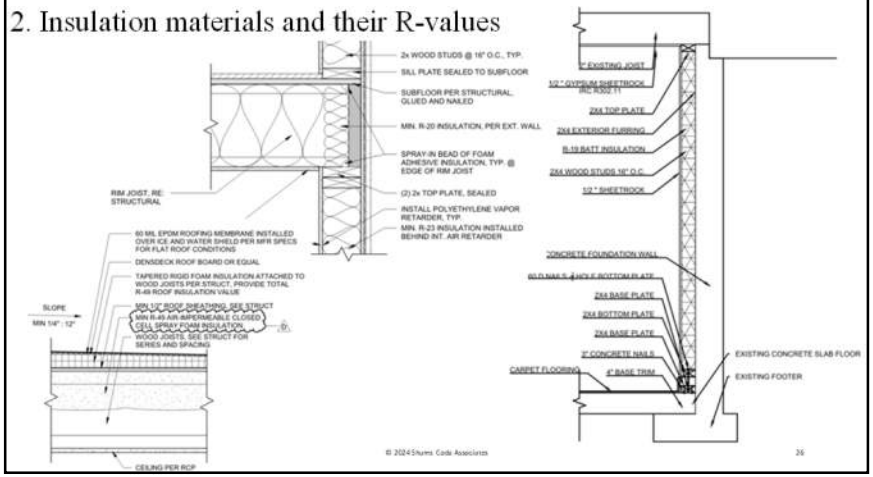
2. Insulation materials and their R-values



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26

3. Fenestration U-factors and solar heat gain coefficients (SHGC).

WINDOW SCHEDULE

Mark	NOMINAL WIDTH	NOMINAL HEIGHT	Head Height	Sill Height	OPERATION	Description	U Value	Egress	Oqaue dot	Tempered
LOWER LEVEL T.O. CONC. SLAB										
001	6'-6"	5'-0"	14'-0 1/4"	9'-0 1/4"	CA	3050 CSMT	.32 MAX.			•
002	6'-0"	5'-0"	8'-0"	3'-0"	CA	3050 CSMT	.32 MAX.	•		
003	9'-0"	5'-0"	8'-0"	3'-0"	CA	3648 CSMT	.32 MAX.			
004	3'-0"	5'-0"	8'-0"	3'-0"	CA	3050 CSMT	.32 MAX.	•		
MAIN LEVEL										
101	7'-0"	5'-6"	8'-0"	2'-6"	CA	3656 CSMT	.32 MAX.			
102	1'-6"	3'-0"	14'-6"	11'-6"	FG	1630 FIXED	.32 MAX.		•	
103	9'-0"	6'-0"	8'-0"	2'-0"	CA	3060 CSMT/FG/CSMT	.32 MAX.			
106	6'-6"	6'-0"	12'-11 3/4"	6'-11 3/4"	CA	3060 CSMT	.32 MAX.			•
107	6'-0"	5'-0"	8'-0"	3'-0"	CA	3050 CSMT	.32 MAX.			
108	6'-0"	7'-0"	9'-0"	2'-0"	CA	3070 CSMT	.32 MAX.	•		
109	2'-0"	2'-0"	8'-6"	6'-6"	FG	2020 FIXED	.32 MAX.			
110	2'-0"	2'-0"	8'-6"	6'-6"	FG	2020 FIXED	.32 MAX.			
111	2'-0"	2'-0"	8'-6"	6'-6"	FG	2020 FIXED	.32 MAX.			
112	5'-0"	5'-0"	8'-6"	3'-6"	CA	2650 CSMT	.32 MAX.			
113	2'-0"	5'-0"	8'-0"	3'-0"	CA	2050 CSMT	.32 MAX.			
114	6'-0"	6'-0"	9'-0"	3'-0"	CA	3060 CSMT	.32 MAX.			•

27

27

4. Area-weighted U-factor and solar heat gain coefficients (SHGC) calculations

	#1 Value		#1 Area		#2 Value		#2 Area		#3 Value		#3 Area		Total Area		Weighted Average Value
Window U-Value	0.31	x	100	+	0.41	x	100	+	0.32	x	100	÷	300	=	0.35

	#1 Value		#1 Area		#2 Value		#2 Area		#3 Value		#3 Area		Total Area		Area Weighted Average
Window SHGC	0.5	x	100	+	0.4	x	100	+	0.28	x	100	÷	300	=	0.39

28

28

5. Mechanical system design criteria

GROUND SNOW LOAD[o]	WIND DESIGN				SEISMIC DESIGN CATEGORY[f]	SUBJECT TO DAMAGE FROM			ICE BARRIER UNDERLAYMENT REQUIRED[h]	FLOOD HAZARDS[g]	AIR FREEZING INDEX[i]	MEAN ANNUAL TEMP[j]
	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[e]		Coincident wet bulb	Indoor winter design dry-bulb temperature	Indoor winter design dry-bulb temperature			Outdoor winter design dry-bulb temperature			Heating temperature difference	
—	—		—	—	—			—			—	
Latitude	Daily range		Indoor summer design relative humidity	Summer design gains	Indoor summer design dry-bulb temperature			Outdoor summer design dry-bulb temperature			Cooling temperature difference	
—	—		—	—	—			—				

29

5. Mechanical system design criteria

Design Conditions

Location:			**Indoor:**	**Heating**	**Cooling**
Denver, CO, US			Indoor temperature (°F)	70	75
Elevation: 5331 ft			Design TD (°F)	73	15
Latitude: 40°N			Relative humidity (%)	30	50
Outdoor:	**Heating**	**Cooling**	Moisture difference (gr/lb)	35.3	-35.9
Dry bulb (°F)	-3	***90***	**Infiltration:**		
Daily range (°F)	-	27 (H)	Method	Simplified	
Wet bulb (°F)	-	59	Construction quality	Average	
Wind speed (mph)	15.0	7.5	Fireplaces	0	

30

6.Mechanical and service water-heating systems and equipment types, sizes and efficiencies.

Heating Equipment Summary

Make	Carrier		
Trade	Carrier		
Model	58MCB040-12x		
AHRI ref	144278		
Efficiency		92.1	AFUE
Heating input		40000	Btuh
Heating output		33156	Btuh
Temperature rise		44	°F
Actual air flow		830	cfm
Air flow factor		0.031	cfm/Btuh
Static pressure		0.70	in H2O
Space thermostat			

Cooling Equipment Summary

Make	Carrier		
Trade	BASE 13 PURON AC		
Cond	24ABB324(A,W)31		
Coil	CAP**2414A**++TDR		
AHRI ref	3250356		
Efficiency		11.0 EER, 13 SEER	
Sensible cooling		18835	Btuh
Latent cooling		2765	Btuh
Total cooling		21600	Btuh
Actual air flow		995	cfm
Air flow factor		0.067	cfm/Btuh
Static pressure		0.70	in H2O
Load sensible heat ratio		1.00	

31

6.Mechanical and service water-heating systems and equipment types, sizes and efficiencies.

Gas conventional (50 gal, 0.59 EF)

Manufacturer	Giant Factories, Inc.	Tank size (gal)	50
Trade name	Giant	Energy factor	0.59
Model	UG60-36LF-P1U	Input (MBtuh)	0.0
AHRI ref. number	463306	1st hour (gal)	86
		Recovery eff. (%)	80

32

7.Equipment and system controls.

T&B	TOP AND BOTTOM
TBC	TOP OF BACK OF CURB
TEL	TELEPHONE
TEM	TEMPERED
TEMP	TEMPERATURE
T&G	TONGUE AND GROOVE
THERM	THERMOSTAT
THK	THICK
THLD	THRESHOLD
TO	TOP OF
TOC	TOP OF CONCRETE
TOS	TOP OF STEEL
TOSL	TOP OF SLAB
TOW	TOP OF WALL
TV	TELEVISION
TYP	TYPICAL

R403.1.1 Programmable thermostat

R403.1.2 Heat pump supplementary heat

R403.2 Hot water boiler temperature reset

 33

33

8. Duct sealing, duct and pipe insulation and location.

Ventilation Testing: Mech. ventilation systems shall be tested and verified to provide the minimum ventilation flow rates reuired by Section N1103.6.

Hot Water Pipe Insulation (Prescriptive): Insulation for hot water pipe with a minimum thermal resistance (R-value) of R-3 shall be applied to the following:

A. Piping larger than 3/4" nominal diameter.

B. Piping from the water heater to kitchen outlets.

C. Piping located outside the conditioned space.

D. Piping from the water heater to a distribution manifold.

E. Piping located under a floor slab.

F. Buried piping.

G. Supply and return piping in recirculation systems other than demand recirculation.

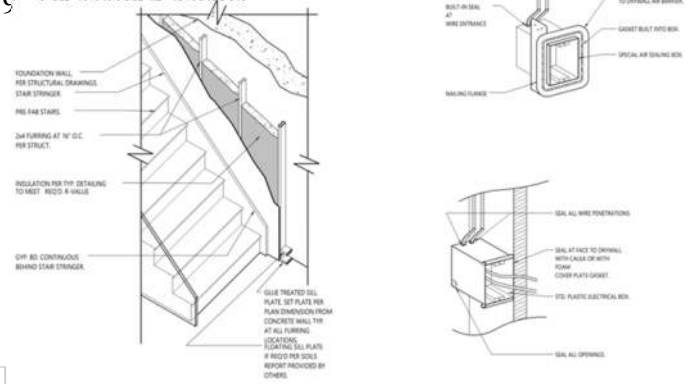
H. Piping with run lengths greater than the maximum run lengths for the nominal pipe diameter given in the following table

Duct Testing: Rough-in test: total leakage shall be measured with a pressure differential of 0.1" w.g. (25 Pa) acrosss the system, including the manuf. air handler enclosure if installed at the time of the test. Registers shall be taped or otherwise sealed during the test. Per N1103.3.5

 34

34

9. Air sealing details



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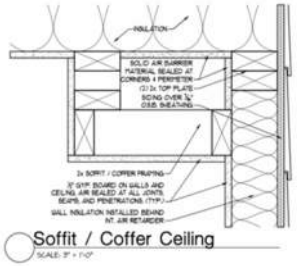
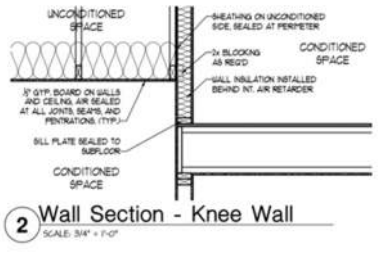
9. Air sealing details





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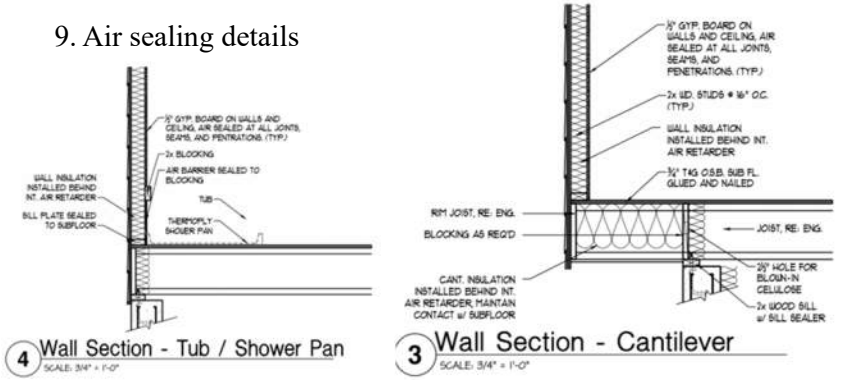
9. Air sealing details



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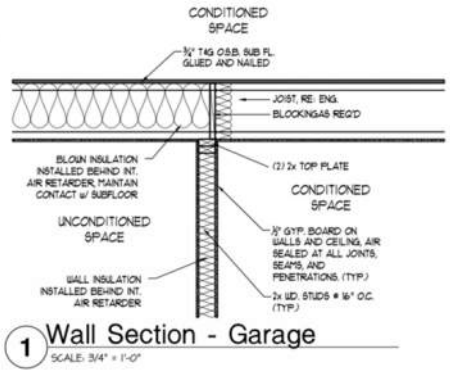
9. Air sealing deta



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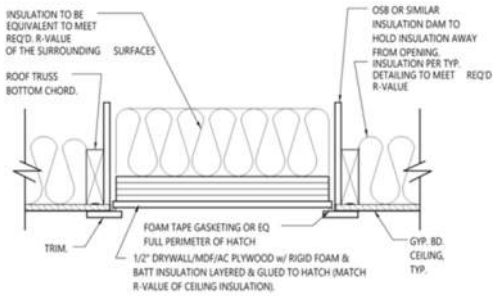
9. Air sealing details



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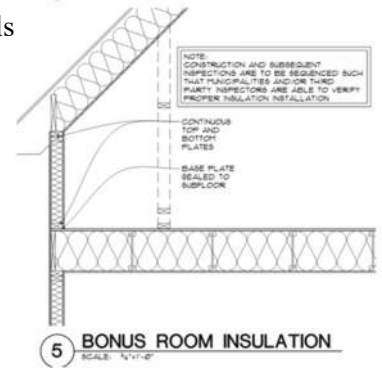
9. Air sealing details



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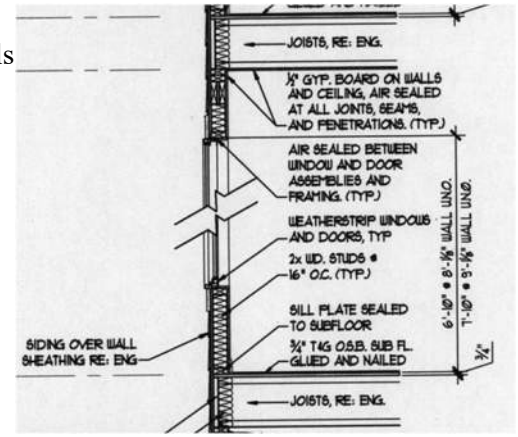
9. Air sealing details



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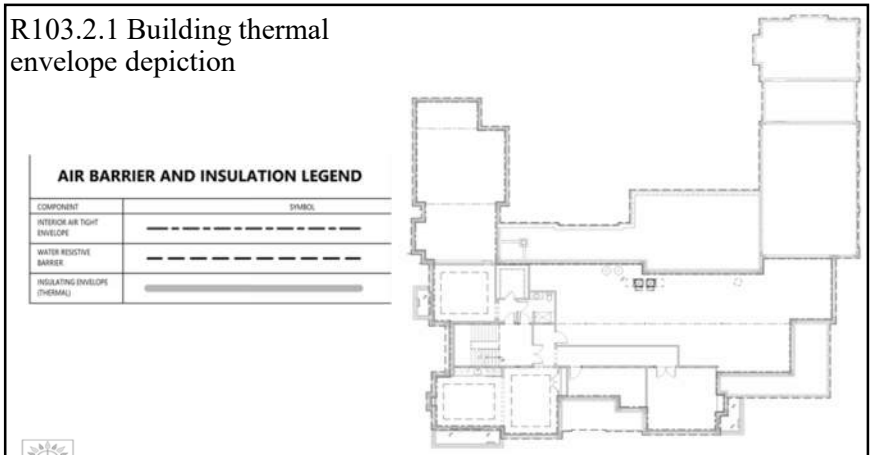
R103.2.1 Building thermal envelope depiction



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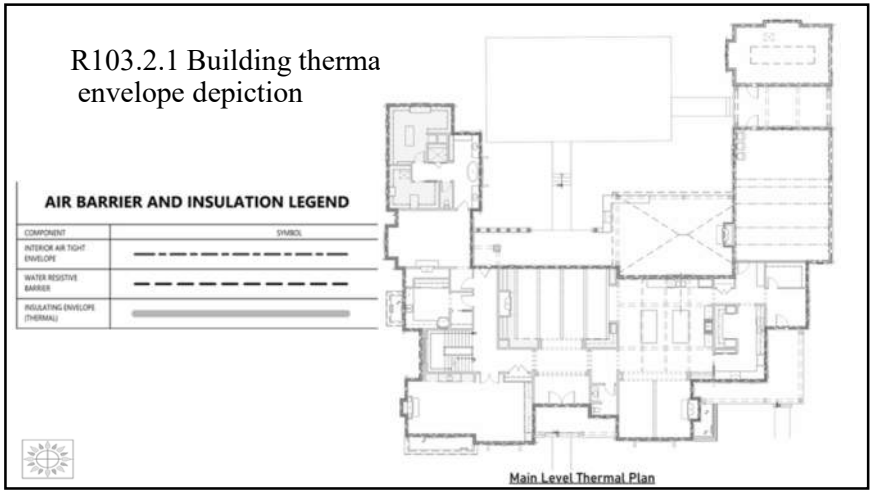
R103.2.1 Building therma envelope depiction



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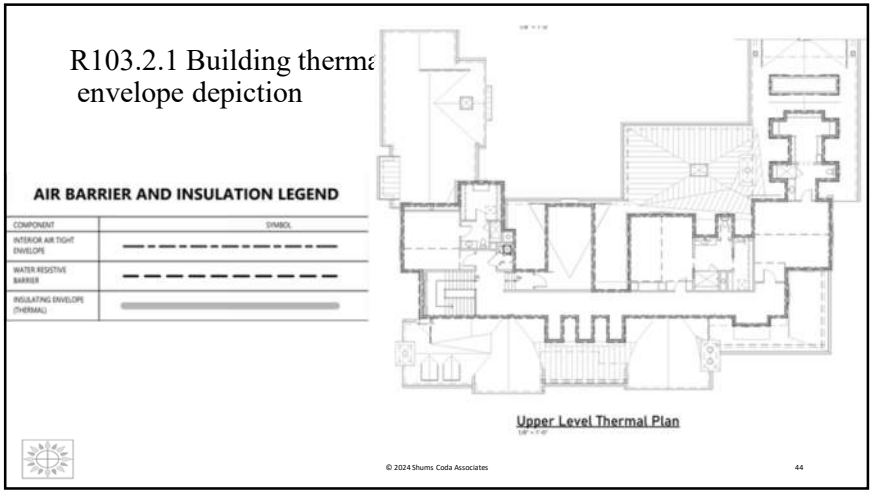
R103.2.1 Building therma envelope depiction



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R103.2.1 Building thermal envelope depiction

Building Section

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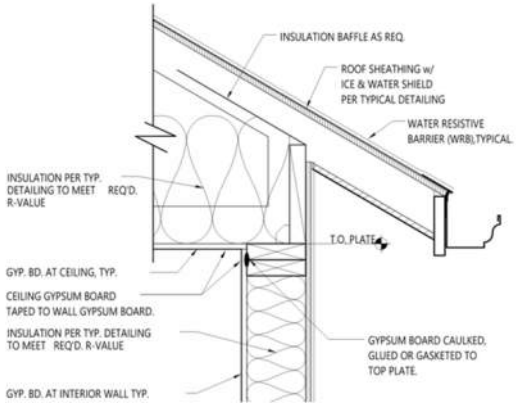
R402.2.3 Eave baffle



…….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. Where soffit venting is not continuous, baffles shall be installed continuously to prevent ventilation air in the eave soffit from bypassing the baffle.

46

46

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

47

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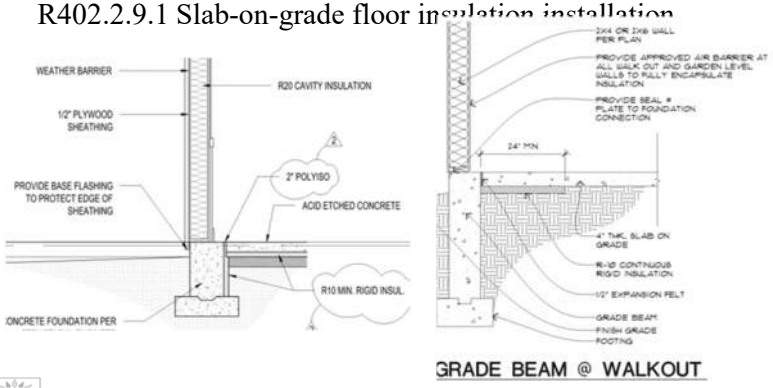
R402.2.4.1 Access hatches and door insulation installation and retention

48

48

R402.2.9.1 Slab-on-grade floor insulation installation



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49

R402.2.12 Sunroom and heated garage insulation

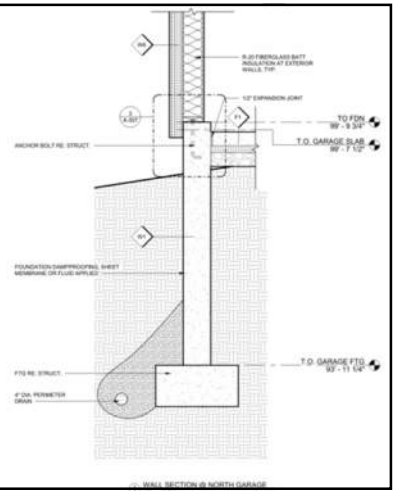
Sunrooms enclosing conditioned space and heated garages shall meet the insulation requirements of this code.

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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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

 51

51

M1505.4.3 Mechanical ventilation rate

TABLE M1505.4.3(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

Ventilation rate in cubic feet per minute =
(0.01 × total square foot area of house) + [7.5 × (number of bedrooms + 1)]

 52

52

Exceptions:

1.Ventilation rate credit. The minimum mechanical ventilation rate determined in accordance with Table M1505.4.3(1) or Equation 15-1 shall be reduced by 30 percent, provided that both of the following conditions apply:

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

1.1.1.Living room.

1.1.2.Dining room.

1.1.3.Kitchen.

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

2.Programmed intermittent operation. The whole-house mechanical ventilation system is permitted to operate intermittently where the system has controls that enable operation for not less than 25 percent of each 4-hour segment and the ventilation rate prescribed in Table M1505.4.3(1), by Equation 15-1 or by Exception 1 is multiplied by the factor determined in accordance with Table M1505.4.3(2)

 53

53

TABLE M1505.4.3(2) INTERMITTENT WHOLE-HOUSE MECHANICAL VENTILATION RATE FACTORS

RUN-TIME PERCENTAGE IN EACH 4-HOUR SEGMENT	25%	33%	50%	66%	75%	100%
Factor[a]	4	3	2	1.5	1.3	1.0

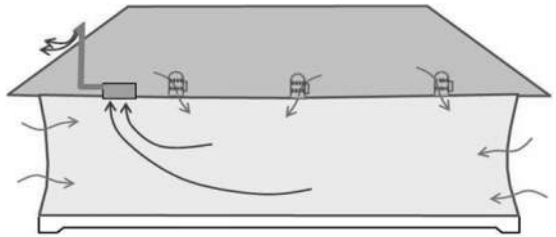
a. For ventilation system run-time values between those given, the factors are permitted to be determined by interpolation.

b. Extrapolation beyond the table is prohibited.

 54

54

Exhaust Only Whole House Ventilation System



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Exhaust Only Whole House Ventilation System

An exhaust only ventilation strategy can be as simple as an exhaust fan that runs continuously or at timed intervals

Advantages:

- Low Cost and easy to install
- Can use infiltration
- Work well in cold climates

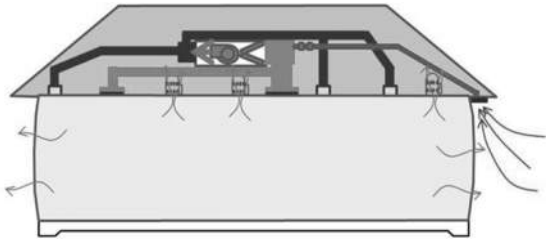
Disadvantages:

- May cause combustion spillage from combustion appliances (Natural Draft type)
- Not appropriate for hot humid climates
- Rely in part on random air leakage

 56

56

Supply Only Whole House Ventilation System



A supply only system can be as simple as connecting an outside air duct to the return air duct

 57

57

Supply Only Whole House Ventilation System

Advantages:

- Low cost and easily installed
- Will not cause negative pressure that could affect combustion appliances
- Allow filtering of pollen and dust in outdoor air
- Allow dehumidification of outdoor air
- Works in hot or mixed climates

 58

58

Supply Only Whole House Ventilation System

Disadvantages:

- Positive pressure could push moisture into the building envelope
- In cold climates if not preheating air, mixed air temperatures could be a problem when using forced air furnace for distribution and outside air duct must be insulated to prevent condensation
- In humid climates increased cooling loads (Latent loads)
- Can increase heating and cooling costs

 59

59

Supply Only Whole House Ventilation System

 60

60

Supply Only Whole House Ventilation System

So how much outside air is too much?????

The code has no guidance, and the manufactures simply say the furnace temperature rise must be within a specified range.

Generally, the outside air flow (cfm) should not be more than 10% of the furnace flow and the outside air duct should be a minimum of 8' to 10' from the heat exchanger.

 61

61

Supply Only Whole House Ventilation System

So here is the math for at least idea of the mixed air temperature:

(Return Air Temperature x 0.9) + (Outside air temperature x 0.1) ≈ mixed Air Temperature

We will assume a return air is 68˚ and the outside air is - 25˚

Solve:

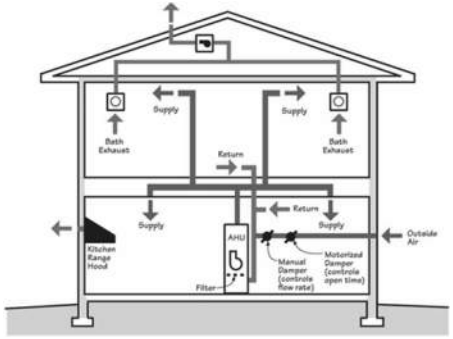
(68 * 0.9) + (-25 * 0.1)

61.2 + -2.5 = 58.7˚ for an approximate mixed air temperature

 62

62

SEMI-BALANCED WHOLE HOUSE VENTILATION SYSTEM



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63

BALANCED WHOLE HOUSE VENTILATION SYSTEM

Semi Balanced

Advantages:

Appropriate for all climate zone

Disadvantages:

Can cost more to install and operate than exhaust or supply systems

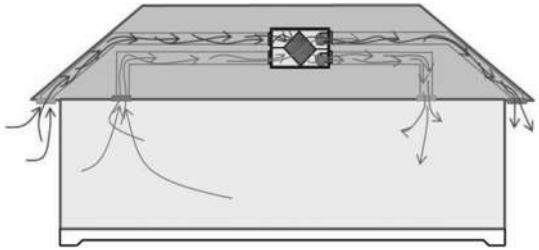
Does not temper or remove moisture from incoming air

Can increase heating and cooling costs

 64

64

BALANCED WHOLE HOUSE VENTILATION SYSTEM



Balanced HRV or ERV

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BALANCED WHOLE HOUSE VENTILATION SYSTEM

Advantages:

- Reduce heating and cooling costs
- Available as either small wall- or window-mounted models or central ventilation systems
- Cost-effective in climates with extreme winters or summers and high fuel costs.

 66

66

BALANCED WHOLE HOUSE VENTILATION SYSTEM

Disadvantages:

- Can cost more to install than other ventilation systems
- May not be cost-effective in mild climates
- Require freeze and frost protection in cold climates
- Require more maintenance than other ventilation systems.

 67

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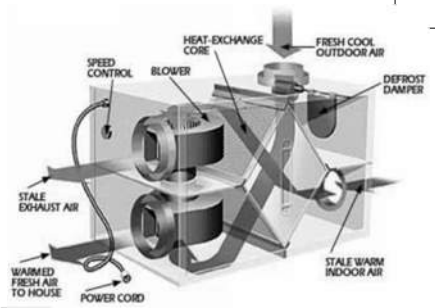
Balanced

- Heat Recovery Ventilator (HRV)

  or
- Energy Recovery Ventilator (ERV)



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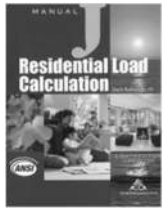
68

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.



 69

69

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

 70

70

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

 71

71

DESIGN LC

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

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

 72

72

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

 73

73

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

 74

74

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

 75

75

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

 76

76

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

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/sizing multiplier	1.00
Equipment sensible load	15832 Btuh

Infiltration

Method	Simplified
Construction quality	Average
Fireplaces	0

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

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

77

77

DESIGN LOADS

Construction descriptions	Or	Area ft²	U-value Btu/ft²·°F	Insul R ft²·°F/Btu	Htg HTM Btu/ft²	Loss Btuh	Clg HTM Btu/ft²	Gain Btuh
Walls								
12F-0sw: Frm wall, wd ext, 1/2" wood shth, r-21 cav ins, 1/2" gypsum board int finsh, 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
15B13-0wc-8: Bg wall, light dry soil, 2"x4" wood int frm, concrete wall, r-13 cav ins, 8" thk, 1/2" gypsum board int finsh	ne	296	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 finsh, 2"x6" wood frm		243	0.068	19.0	2.38	578	1.02	248
Windows								
Low E u 32 SHGC 40: 1 glazing, clr glz, mtl no brk frm mat, 1/8" thk; NFRC rated (SHGC=0.40); 50% blinds 45°, medium; 50% outdoor insect screen; 2 ft overhang (3 ft window ht, 2 ft sep.)								

There are hundreds of construction descriptions. They should match the construction plans.

A Partition is a wall that separates a conditioned area from a unconditioned area. This would be typical of a wall between the house and the garage.

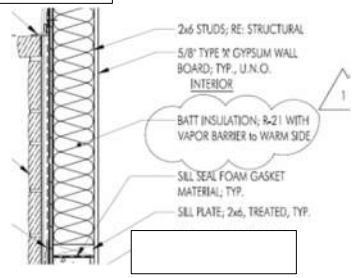
Verify that the designer has taken credit for blinds, screens and overhangs.

78

78

DESIGN LOADS

Construction descriptions	Or	Area ft²	U-value Btu/ft²·°F	Insul R ft²·°F/Btu	Htg HTM Btu/ft²	Loss Btuh	Clg HTM Btu/ft²	Gain Btuh
Walls								
12F-0sw: Frm wall, wd ext, 1/2" wood shth, r-21 cav ins, 1/2" gypsum board int finsh, 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



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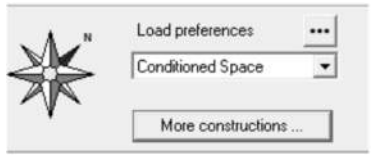
DESIGN LOADS

Construction descriptions	Or	Area ft²	U-value Btu/ft²·°F	Insul R ft²·°F/Btu	Htg HTM Btu/ft²	Loss Btuh	Clg HTM Btu/ft²	Gain Btuh
Walls								
12F-0sw: Frm wall, wd ext, 1/2" wood shth, r-21 cav ins, 1/2" gypsum board int finsh, 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
15B13-0wc-8: Bg wall, light dry soil, 2"x4" wood int frm, concrete wall, r-13 cav ins, 8" thk, 1/2" gypsum board int finsh	ne	296	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 finsh, 2"x6" wood frm		243	0.068	19.0	2.38	578	1.02	248
Windows								

In Wrightsoft there is a command to turn the house in the direction with the highest loads. It is not unusual for production builders to do this.

HTM = Heat Transfer Modifier
All of the Manual J formulas boil down to an HTM. The HTM times the area equals the heat loss or gain.



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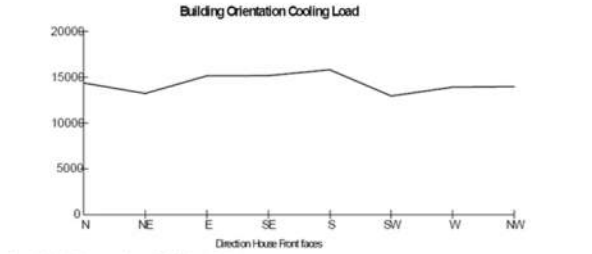
House Front	North	Northeast	East	Southeast	South	Southwest	West	Northwest
Sensible Load (Btuh)	14385	13243	15156	15192	15832	12963	13933	13976
Latent Load (Btuh)	0	0	0	0	0	0	0	0
Total Load (Btuh)	14385	13243	15156	15192	15832	12963	13933	13976
Heating AVF (cfm)	830	830	830	830	830	830	830	830
Cooling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



Current Orientation: House Front faces South
Highest Cooling Load: House Front faces South

 81

81

DESIGN LOADS

 82

82

DESIGN LOADS

6	c) AED excursion						1812				523
	Envelope loss/gain					22399	10908			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

 83 83

83

DESIGN LOADS

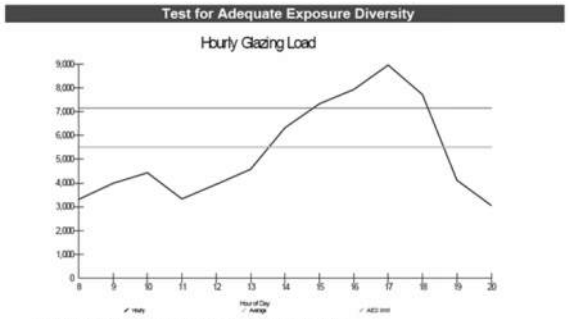
- Adequate Exposure Diversity

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.

 84

84

DESIGN LOADS



 85

85

DESIGN LOADS

- Questions on design loads ?

86

Equipment Selection **Heating**

The required load (Heat Loss) on our example house is 31,066 Btuh.

I have selected a Carrier (No reason but that I had all the performance specifications) model 58MCB 040-12.

This unit has a 40,000 Btuh input rating and has an efficiency rating of 92.1 AFUE.

..\..\..\Carrier Equipment\Carrier - 58MCB - Product Data.pdf

 87

87

Equipment Selection **Heating**

The output rating will be about 33,156 Btuh after de-rating for efficiency and for altitude.

40,000 x .921 = 36,840 x .90 = 33,156 Btuh

So what is the correct adjustment for altitude?? Manual S does have generic deration factors but only if the manufacturer does not provide any deration information. See the footnotes in the performance data.

Per Manual S it is acceptable to size up to 140% the MJ8 required load

31,066 x 1.4 = 43,492 > 33,156 Btuh

 88

88

Equipment Selection **Heating**

Performance data

UNIT SIZE			040-08	040-12	060-08	060-12	060-16	080-12	080-16	080-20	100-16	100-20	120-20	140-20
CERTIFIED TEMP RISE RANGE (°F)			30—60	15—45	45—75	30—60	20—50	40—70	30—60	20—50	45—75	30—60	40—70	50—80
CERTIFIED EXT STATIC PRESSURE (in. wc)		Heating	0.10	0.10	0.12	0.12	0.12	0.15	0.15	0.15	0.20	0.20	0.20	0.20
		Cooling	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
AIRFLOW CFM‡		Heating	850	1125	885	1065	1320	1190	1285	1785	1315	1690	1720	1970
		Cooling	895	1215	900	1200	1545	1245	1525	1925	1570	1930	2000	1990

EFFICIENCY

UNIT SIZE			040-08	040-12	060-08	060-12	060-16	080-12	080-16	080-20	100-16	100-20	120-20	140-20
OUTPUT CAPACITY BTUH* (ICS) (Shaded capacities are specified on rating plate)	Direct Vent (2-Pipe)	Upflow	37,000	37,000	56,000	56,000	56,000	74,000	74,000	74,000	93,000	93,000	112,000	127,000
		Downflow	37,000	37,000	56,000	56,000	56,000	74,000	74,000	74,000	93,000	93,000	112,000	127,000
		Horizontal	37,000	37,000	56,000	56,000	56,000	74,000	74,000	74,000	93,000	93,000	112,000	127,000
	Non-Direct Vent (1-Pipe)	Upflow	37,000	37,000	56,000	56,000	56,000	74,000	74,000	74,000	93,000	93,000	112,000	NA
		Downflow	37,000	37,000	56,000	56,000	56,000	74,000	74,000	74,000	93,000	93,000	112,000	NA
		Horizontal	37,000	37,000	56,000	56,000	56,000	74,000	74,000	74,000	93,000	93,000	112,000	NA
INPUT BTUH†			40,000	40,000	60,000	60,000	60,000	80,000	80,000	80,000	100,000	100,000	120,000	120,000
AFUE% Nonweatherized ICS	Direct Vent (2-Pipe)	Upflow	92.3	92.3	92.3	92.3	92.3	92.3	92.3	92.3	92.3	92.3	92.3	92.3
		Downflow	91.2	91.2	91.2	91.2	91.2	91.2	91.2	91.2	91.2	91.2	91.2	91.2
		Horizontal	92.1	92.1	92.1	92.1	92.1	92.1	92.1	92.1	92.1	92.1	92.1	92.0
	Non-Direct Vent (1-Pipe)	Upflow	92.1											NA
		Downflow	91.0											NA
		Horizontal	91											NA

* Capacity and AFUE in accordance with U.S. Government DOE test procedures.
† Gas input ratings are certified for elevations to 2000 ft. For elevations above 2000 ft, reduce ratings 2% for each 1000 ft above sea level. In Canada, derate the unit 5% for elevations 2000 to 4500 ft above sea level.
‡ Airflow shown is for bottom only return-air supply. For air delivery above 1800 CFM, see Air Delivery table for other options. A filter is required for each return-air supply.
ICS—Isolated Combustion System

89

Equipment Selection **Heating**

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

Heating Equipment Summary

Make	Carrier	
Trade	Carrier	
Model	58MCB040-12x	
AHRI ref no.	144278	
Efficiency	92.1	AFUE
Heating input	40000	Btuh
Heating output	33156	Btuh
Temperature rise	44	°F
Actual air flow	830	cfm
Air flow factor	0.031	cfm/Btuh
Static pressure	0.70	in H2O
Space thermostat		

Temperature Rise:
The difference in the air temperature entering the heat exchanger and the air leaving the heat exchanger.
Heat (temperature) Rise Formula:
Btuh/cfm/(1.1xACF) = Temperature Rise
Where:
Btuh = Heating output
CFM = Actual Air Flow in Cubic Feet per Minute
1.1 is a formula constant at sea level
ACF = Altitude Correction Factor from Table 10A (5000' = .832)

33,156/830/(1.1x.832) = 43.6 degrees F

90

Equipment Selection **Heating**

Temperature Rise is the difference in the return air entering heat exchanger and the air leaving the heat exchanger.

91

Equipment Selection **Heating**

Heating Equipment Summary

Make	Carrier	
Trade	Carrier	
Model	58MCB040-12x	
AHRI ref no.	144278	
Efficiency	92.1	AFUE
Heating input	40000	Btuh
Heating output	33156	Btuh
Temperature rise	44	°F
Actual air flow	830	cfm
Air flow factor	0.031	cfm/Btuh
Static pressure	0.70	in H2O
Space thermostat		

Actual Air flow is from the manufacturers performance data at a specific static pressure

92

Equipment Selection **Heating**

Performance data

UNIT SIZE			040-08	040-12	060-08	060-12	060-16	080-12	080-16	080-20	100-16	100-20	120-20
CERTIFIED TEMP RISE RANGE (°F)			30—60	15—45	15—75	30—60	20—50	40—70	30—60	20—50	45—75	30—60	40—70
CERTIFIED EXT STATIC PRESSURE (In. wc)	Heating		0.10	0.10	0.12	0.12	0.12	0.15	0.15	0.15	0.20	0.20	0.20
	Cooling		0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
AIRFLOW CFM‡	Heating		850	1125	885	1065	1320	1190	1285	1785	1315	1690	1720
	Cooling		895	1215	900	1200	1545	1245	1525	1925	1570	1930	2000

AIR DELIVERY—CFM (With Filter)*

UNIT SIZE	RETURN-AIR SUPPLY	SPEED	EXTERNAL STATIC PRESSURE (In. wc) 0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8
040-08	1 side or bottom	High	1075	1040	995	945	895	840	780	670
		Med-Low	850	825	780	740	685	635	560	480
		Low	740	700	650	620	565	515	455	385
040-12	1 side or bottom	High	1470	1415	1400	1285	1215	1120	995	890
		Med-High	1315	1280	1235	1180	1115	1035	930	825
		Med-Low	1125	1110	1085	1045	990	915	830	740
		Low	930	905	910	850	830	770	705	635
060-08	1 side or bottom	High	1100	1065	1005	945	900	805	720	610
		Med-Low	890	865	810	765	705	620	540	475
		Low	745	710	670	625	565	505	425	360
060-12	1 side or bottom	High	1430	1375	1325	1275	1200	1135	1040	935
		Med-High	1270	1260	1215	1160	1105	1035	950	855
		Med-Low	1070	1055	1045	1015	975	920	850	750
		Low	915	895	885	865	840	800	720	650
060-16	1 side or bottom	High	1700	1695	1640	1580	1545	1450	1380	1310
		Med-High	1500	1465	1435	1385	1355	1300	1250	1185
		Med-Low	1325	1295	1265	1230	1190	1150	1105	1050
		Low	1205	1170	1145	1110	1080	1035	990	950
080-12	1 side or bottom	High	1535	1470	1405	1330	1245	1160	1065	935
		Med-High	1395	1350	1300	1225	1155	1080	985	880
		Med-Low	1200	1175	1125	1065	1030	970	890	780
		Low	1040	1020	990	960	910	860	785	680
	1 side	High	1750	1685	1635	1575	1525	1445	1380	1310

SHADE

93

Equipment Selection **Heating**

Questions on Heating equipment selection ?

Heating Equipment Summary

Make	Carrier
Trade	Carrier
Model	58MCB040-12x
AHRI ref no.	144278

Efficiency	92.1	AFUE
Heating input	40000	Btuh
Heating output	33156	Btuh
Temperature rise	44	°F
Actual air flow	830	cfm
Air flow factor	0.031	cfm/Btuh
Static pressure	0.70	in H2O
Space thermostat		

94

Equipment Selection **Cooling**

Cooling Equipment Summary

Make	Carrier
Trade	BASE 13 PURON AC
Cond	24ABB324(A,W)31
Coil	CAP**2414A**++TDR
AHRI ref no.	3250356

Efficiency	11.0 EER, 13 SEER	
Sensible cooling	18835	Btuh
Latent cooling	2765	Btuh
Total cooling	21600	Btuh
Actual air flow	995	cfm
Air flow factor	0.067	cfm/Btuh
Static pressure	0.70	in H2O
Load sensible heat ratio	1.00	

..\..\..\Carrier Equipment\24abb3-7pd.pdf

95

Equipment Selection **Cooling**

- Earlier we concluded that the MJ8 sensible heat ratio (JSHR) was 1.00
- The intent is to pick cooling equipment with the same (or as close as we can) SHR at a specified cfm.

96

Equipment Selection **Cooling**

Our target loads:
Total = 15,832 Btuh Sensible = 15,832 Btuh Latent = 0.00 Btuh

DETAILED COOLING CAPACITIES# CONTINUED

EVAPORATOR AIR		CONDENSER ENTERING AIR								
		75 (23.9)			85 (29.4)			95 (35)		
CFM	EWB °F (°C)	Capacity MBtuh		Total System KW**	Capacity MBtuh		Total System KW**	Capacity MBtuh		Total System KW**
		Total	Sens‡		Total	Sens‡		Total	Sens‡	
		24ABB324(A,W)31 Outdoor Section With CAP**24								
700	72 (22.2)	27.09	13.27	1.65	25.82	12.82	1.85	24.63	12.41	2.06
	67 (19.4)	24.89	16.41	1.65	23.83	15.99	1.84	22.71	15.56	2.05
	63 (17.2)††	23.39	15.98	1.64	22.38	15.55	1.84	21.29	15.11	2.05
	62 (16.7)	23.01	19.56	1.64	22.03	19.14	1.84	20.99	18.67	2.05
	57 (13.9)	22.46	22.46	1.64	21.66	21.66	1.83	20.79	20.79	2.05
800	72 (22.2)	27.52	13.92	1.69	26.15	13.46	1.88	24.91	13.04	2.10
	67 (19.4)	25.25	17.44	1.68	24.16	17.03	1.88	23.00	16.60	2.09
	63 (17.2)††	23.76	16.95	1.68	22.72	16.53	1.87	21.60	16.08	2.09
	62 (16.7)	23.47	20.99	1.68	22.49	20.52	1.87	21.52	21.52	2.09
	57 (13.9)	23.30	23.30	1.68	22.44	22.44	1.87	21.53	21.53	2.09

We will start with 800 cfm value. (We will adjust for altitude later)

EBW = Entering Wet Bulb temperature. We will use the 63° value
(Close enough & see footnote)

Remember we said that 75° dry bulb at 50% RH is psychometrically equal to 62° wet bulb.

97

Equipment Selection **Cooling**

DETAILED COOLING CAPACITIES# CONTINUED

EVAPORATOR AIR		CONDENSER ENTERING AIR								
		75 (23.9)			85 (29.4)			95 (35)		
CFM	EWB °F (°C)	Capacity MBtuh		Total System KW**	Capacity MBtuh		Total System KW**	Capacity MBtuh		Total System KW**
		Total	Sens‡		Total	Sens‡		Total	Sens‡	
		24ABB324(A,W)31 Outdoor Section With CAP**24								
700	72 (22.2)	27.09	13.27	1.65	25.82	12.82	1.85	24.63	12.41	2.06
	67 (19.4)	24.89	16.41	1.65	23.83	15.99	1.84	22.71	15.56	2.05
	63 (17.2)††	23.39	15.98	1.64	22.38	15.55	1.84	21.29	15.11	2.05
	62 (16.7)	23.01	19.56	1.64	22.03	19.14	1.84	20.99	18.67	2.05
	57 (13.9)	22.46	22.46	1.64	21.66	21.66	1.83	20.79	20.79	2.05
800	72 (22.2)	27.52	13.92	1.69	26.15	13.46	1.88	24.91	13.04	2.10
	67 (19.4)	25.25	17.44	1.68	24.16	17.03	1.88	23.00	16.60	2.09
	63 (17.2)††	23.76	16.95	1.68	22.72	16.53	1.87	21.60	16.08	2.09
	62 (16.7)	23.47	20.99	1.68	22.49	20.52	1.87	21.52	21.52	2.09
	57 (13.9)	23.30	23.30	1.68	22.44	22.44	1.87	21.53	21.53	2.09

The air entering the condenser (the outdoor unit) is the outside dry bulb design temperature

Remember for Denver the outdoor design temperature is 90° dry bulb. Per Manual S we can be with in 5°. We will use the 95° value.

At first glance this equipment has a SHR of 16,080 / 21,600 = .74
Now look at the footnote ‡

†† At TVA rating indoor condition (75°F edb/63°F ewb). All other indoor air temperatures are at 80°F edb.

98

Equipment Selection **Cooling**

Per Manual S one half of the excess latent capacity can be converted to sensible capacity as this is self-correcting.

Solve for today's example:

Total capacity of 21,600 – Sensible capacity of 16,080 = 5,520 Latent capacity

5,520/2= 2,760 16,080 + 2,760 = 18,840 new sensible capacity

New SHR 18,840 / 21,600 = .87

Per Manual S we can be up to 15% oversized:
Target total load of 15,832 x 1.15 = 18,206 Btuh < 21,600 Btuh

So we are technically slightly oversized……

In reality as long as we are within 6,000 Btuh we are in good shape

99

Equipment Selection **Cooling**

- What about the effects of altitude?
  - If you are moving 1000 cfm at sea level are you moving 1000 cfm at 5000'?
  - Air at altitude is less dense
  - So you need to move more air at altitude to get the same performance or derate the capacity

100

Equipment Selection **Cooling**

- All of the performance data provided by the manufacturers is performance at sea level.
- Adjustments must be made for performance at altitude.
- Unfortunately very few if any manufactures provide any guidance for altitude adjustment for air conditioners.
- Fortunately Manual S does in appendix 6

 101

101

Equipment Selection **Cooling**

The formula for air density correction:

- CFM at Altitude = Sea-Level Flow Rate / Density Ratio

- The air density correction factor for 5000' is .832

Solve for example house:

- 800/.832 = 962 cfm

 102

102

Equipment Selection Cooling

Remember this?

Sensible Heat Equation to calculate a preliminary cooling CFM
CFM = 15,832/ (1.1 x .832 x 17) = 1,017 cfm

This gave us an approximate CFM for cooling. So a fan speed anywhere from 962 cfm to 1,017 cfm will work for the AC speed.

 103

103

Equipment Selection **Cooling**

Now we have determined that our cooling equipment will have the capacity needed at 962 to 1,017 cfm. The question now is will the blower deliver?

AIR DELIVERY—CFM (With Filter)*

UNIT SIZE	RETURN-AIR SUPPLY	SPEED	EXTERNAL STATIC PRESSURE (In. wc)							
			0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8
040-08	1 side or bottom	High	1075	1040	995	945	895	840	760	670
		Med-Low	850	825	780	740	685	635	560	480
		Low	740	700	650	620	565	515	455	385
040-12	1 side or bottom	High	1470	1415	1400	1285	1215	1120	995	890
		Med-High	1315	1280	1235	1180	1115	1035	930	825
		Med-Low	1125	1110	1085	1045	990	915	830	740
		Low	930	925	910	850	830	770	705	635
[illegible]	1 side	High	1100	1065	1005	945	900	805	730	610

Remember earlier we used .7 IWC for heat cfm. It appears if we set the blower at High it will deliver 995 cfm. Works for me!

 104

104

Equipment Selection **Cooling**

Questions on cooling equipment selection ?

Cooling Equipment Summary

Make	Carrier	
Trade	BASE 13 PURON AC	
Cond	24ABB324(A,W)31	
Coil	CAP**2414A**++TDR	
AHRI ref no.	3250356	
Efficiency	11.0 EER, 13 SEER	
Sensible cooling	18835	Btuh
Latent cooling	2765	Btuh
Total cooling	21600	Btuh
Actual air flow	995	cfm
Air flow factor	0.067	cfm/Btuh
Static pressure	0.70	in H2O
Load sensible heat ratio	1.00	

105

Manual D **Duct Sizing**

Now that we have determined the house loads and selected the proper sized equipment, how do make certain the needed cfm is delivered to each room?

Manual D provides us with design parameters and calculations that will result in a duct system that will provide adequate air flows to rooms. Not designing your ductwork at this stage can have disastrous results like:

- Undersized ductwork effects furnace temperature rise (to high)
- Undersized ductwork effects cooling capacity (freezing coil)
- Equipment efficiency is lessened – more energy is used and comfort levels go down
- Unacceptable noise levels

106

Manual D **Duct Sizing**

Manual D requires that the duct system be equipped with balancing dampers. Manual D will get you close but is not perfect. Some duct over sizing will occur with balancing dampers the flow can be adjusted.

How many contractors actually use balancing dampers one their systems?? In my experience very few, this is not a bad thing but the builder may have some comfort issues.

107

Manual D **Duct Sizing**

Steps in duct design:

- Determine cfm flow to each room
- Make a rough sketch of duct runs- supplies and returns. I encourage designers to do this on the framing plan to avoid structural members.
- Collect information on blower and all air side pressure drops. This would be the coil, air filters, registers and grills.

108

Manual D **Duct Sizing**

- Determine the total equivalent length of the duct work. This is the longest supply path plus the longest return path. Don't forget the fittings.
- Determine the friction rate. You will need to know available static pressure.
- Size all ductwork based on needed flow and friction rate.

See how easy it is!!!!

109

Manual D **Duct Sizing**

A reasonably well designed system will be within these parameters:

- Total system flow will be ± 5% of design flow.
- Room flows will be ± 10% of design flow. (I have allowed ± 20%)
- Total system static will be ± 0.10 IWC of design.
- Duct velocities are within Manual D recommendations.

110

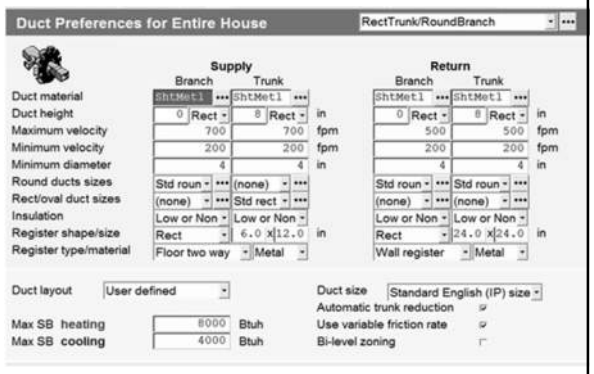
Manual D **Duct Sizing**

Recommended Velocities (FPM)								
	Supply Side				Return Side			
	Recommended		Maximum		Recommended		Maximum	
	Rigid	Flex	Rigid	Flex	Rigid	Flex	Rigid	Flex
Trunk Ducts	700	600	900	700	600	600	700	700
Branch Ducts	600	600	900	700	400	400	700	700
Supply Outlet Face Velocity	Size for throw		700		--------		--------	
Return Grille Face Velocity	--------		--------		--------		500	
Filter Grille Face Velocity	--------		---------		-------		300	

Copy of Table 3-1 from ACCA Manual D

111

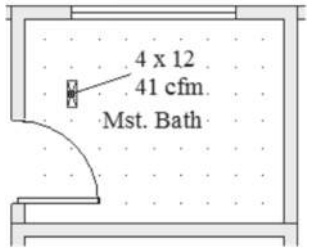
Manual D **Duct Sizing**



112

Manual D **Duct Sizing**

The required cfm to each room is relative to the rooms calculated load. Essentially if the room requires 5% of the equipments capacity the room will need 5% of the blower cfm.



113

Manual D **Duct Sizing**

To determine the required cfm per room you must calculate the heating and cooling factors. (Wrightsoft labels this as 'Air Flow Factor')

Heating Factor = Blower Cfm/ MJ8 Heat Loss (for structure)
Cooling Factor = Blower Cfm/ MJ8 Sensible Load (for structure)

Solve for today's house
Heating Factor = 830/26,853 = .031
Cooling Factor = 995/14,954 = .067

114

Manual D **Duct Sizing**

The Wrightsoft program does most of the work for you. The proper inputs are critical.

Determine your available static pressure:

- Start with the static pressure you used for the equipment. Remember we used .7 IWC.
- Enter the AC coil resistance. This found in the manufactures performance data.
- Enter heat exchanger resistance. Ours was included with the performance data.

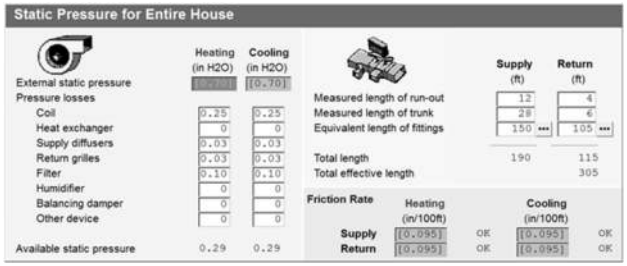
115

Manual D **Duct Sizing**

- Enter supply registers and return grille resistance. We will use .03 IWC.
- Enter filter resistance. Most performance data includes 'cost effective' filter.
- Enter humidifier resistance, from manufactures performance data.
- Enter balancing dampers if used.
- Any other devices like air cleaners etc.

116

Manual D **Duct Sizing**



117

Manual D **Duct Sizing**

This is the friction rate formula: ASP x 100/TEL

Where:

- ASP = Available static pressure
- 100 = The friction rate is per 100' of duct length
- TEL = Total Equivalent Length of ductwork

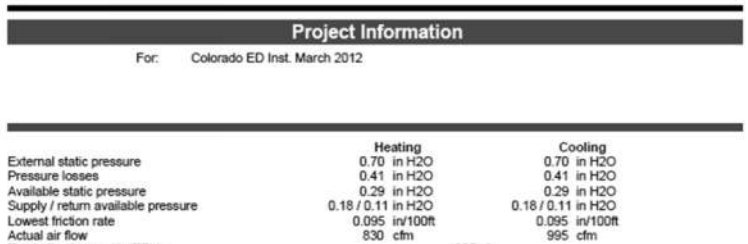
Solve:

.29 x 100/305 = .095

Per Manual D the friction rate must be not less than 0.06 and not more than 0.18.

118

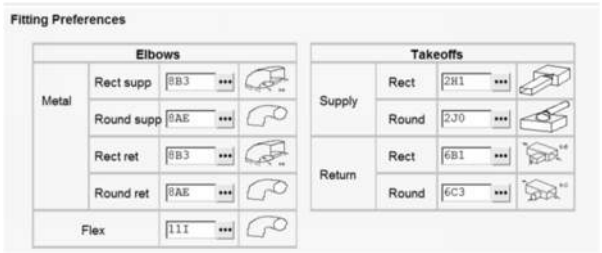
Manual D **Duct Sizing**



119

Manual D **Duct Sizing**

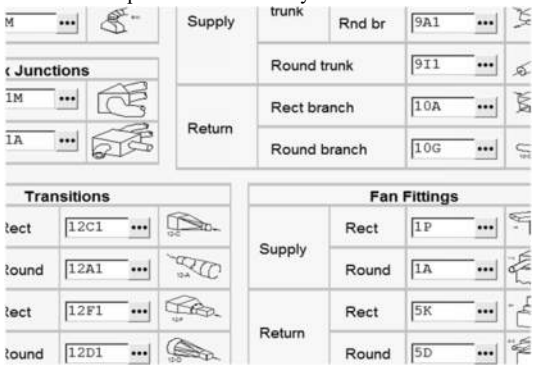
Duct preferences for today's house



120

Manual D **Duct Sizing**

Duct preferences for today's house



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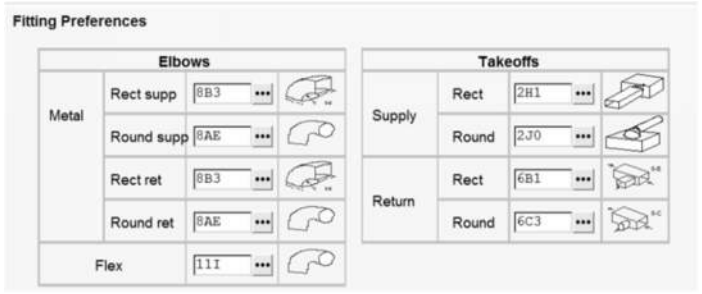
121

Manual D **Duct Sizing**



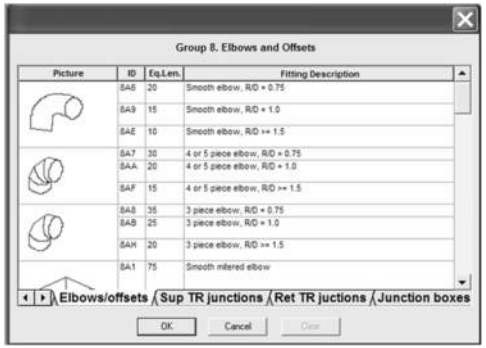
- Note: Round Supply 8AE

 122

122

Manual D **Duct Sizing**

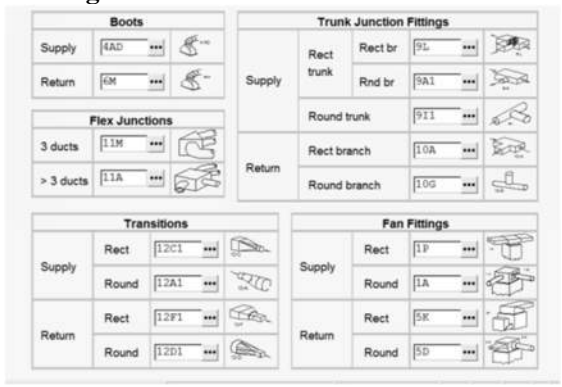
Equivalent lengths for elbows and offsets.



 123

123

Manual D **Duct Sizing**

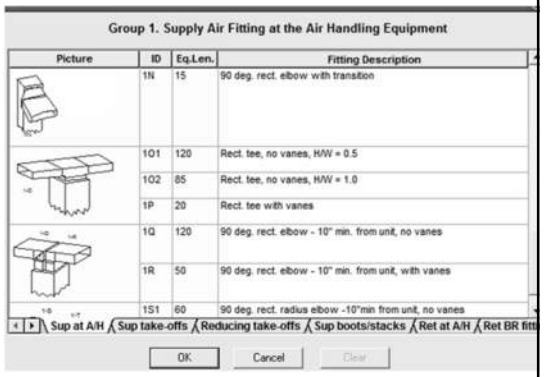


- Note: Supply Fan Fitting 1P

 124

124

Manual D **Duct Sizing**



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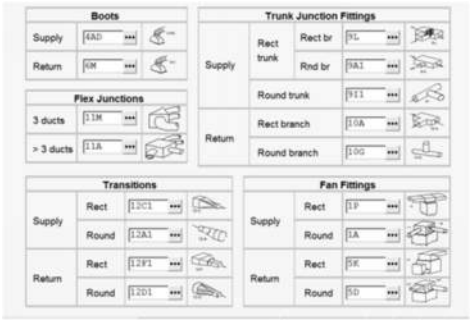
125

Manual D **Duct Sizing**

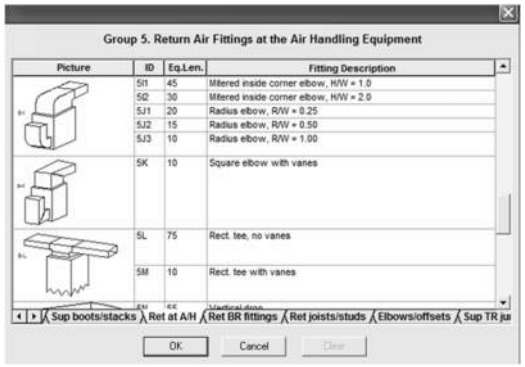


- Note: Supply Fan Fitting 5K

126

126

Manual D **Duct Sizing**



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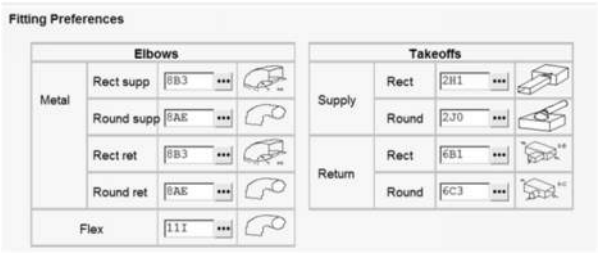
127

Manual D **Duct Sizing**

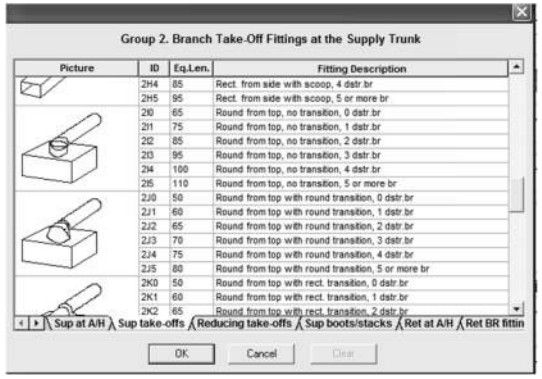


- Note: Round Supply 2JO

128

128

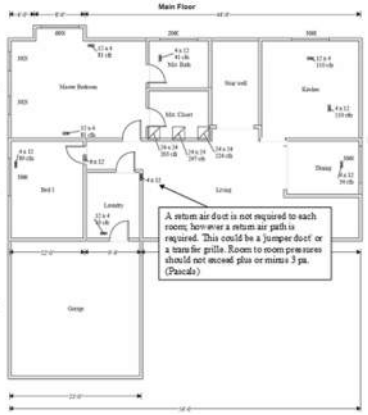
Manual D **Duct Sizing**



129

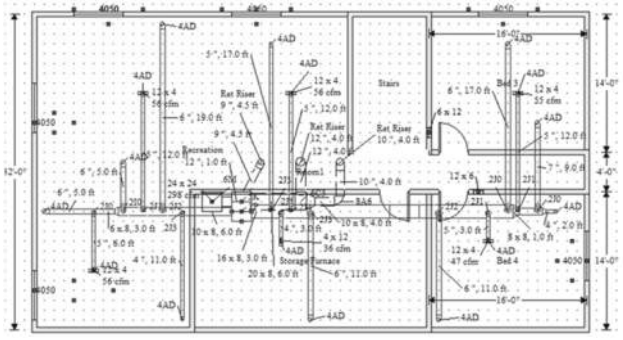
Manual D **Duct Sizing**

Today's House



130

Manual D **Duct Sizing**



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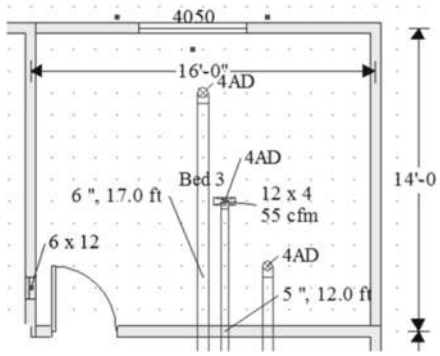
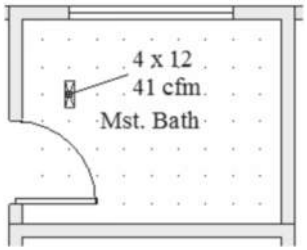
Manual D **Duct Sizing**



132

Questions on duct design?



 133

133

R404.2 Interior lighting controls

Permanently installed lighting fixtures shall be controlled with either a dimmer, an occupant sensor control or other control that is installed or built into the fixture.

Exception: Lighting controls shall not be required for the following:

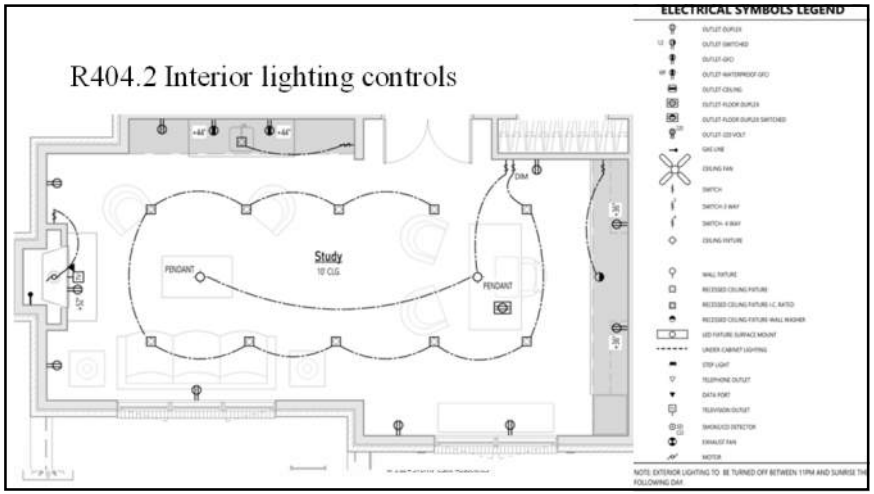
1. Bathrooms.
2. Hallways.
3. Exterior lighting fixtures.
4. Lighting designed for safety or security.

ALL PERMANENTLY INSTALLED LIGHTING FIXTURES SHALL CONTAIN ONLY HIGH-EFFICIENCY LIGHTING SOURCES. N1104.1.1
PERMANENTLY INSTALLED INTERIOR LIGHTING FIXTURES SHALL COMPLY WITH IRC N1104.2
EXTERIOR LIGHTING FIXTURES THAT HAVE 30 WATTS OR MORE OF POWER SHALL BE INSTALLED WITH AUTOMATIC SHUT OFF DURING DAYLIGHT HOURS PER N1104.3

 134

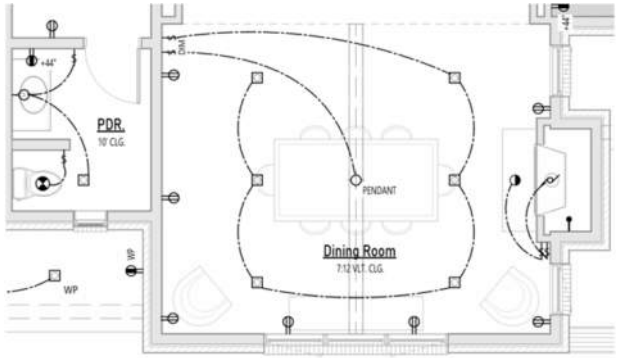
134

R404.2 Interior lighting controls



135

R404.2 Interior lighting controls



136

136

R404.3 Exterior lighting controls

ALL PERMANENTLY INSTALLED LIGHTING FIXTURES SHALL CONTAIN ONLY HIGH-EFFICIENCY LIGHTING SOURCES. N1104.1.1
PERMANENTLY INSTALLED INTERIOR LIGHTING FIXTURES SHALL COMPLY WITH IRC N1104.2
EXTERIOR LIGHTING FIXTURES THAT HAVE 30 WATTS OR MORE OF POWER SHALL BE INSTALLED WITH AUTOMATIC SHUT OFF DURING DAYLIGHT HOURS PER N1104.3

Where the total permanently installed exterior lighting power is greater than 30 watts, the permanently installed exterior lighting shall comply with the following:

1.Lighting shall be controlled by a manual on and off switch which permits automatic shut-off actions.

Exception: Lighting serving multiple dwelling units.

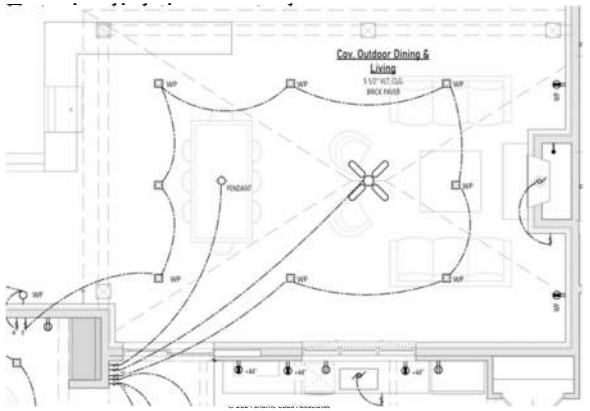
2.Lighting shall be automatically shut off when daylight is present and satisfies the lighting needs.

3.Controls that override automatic shut-off actions shall not be allowed unless the override automatically returns automatic control to its normal operation within 24 hour

 137

137

R404.3



138

138

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.

 139

139

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.

 140

140

R408 Additional Efficiency Package Options

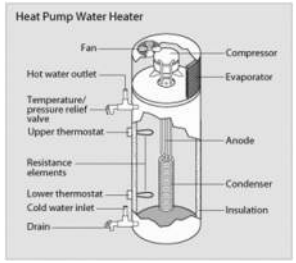
R408.2.3 Reduced energy use in service water-heating option

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.



 141

141

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.

 142

142

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).

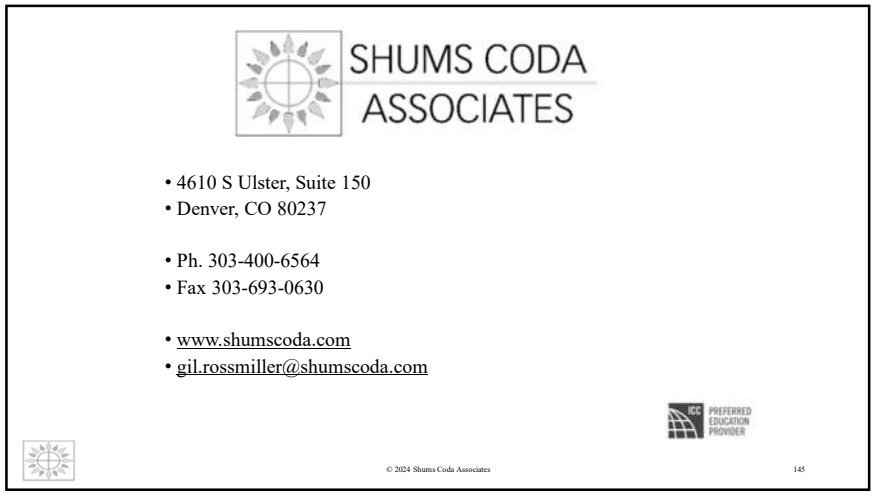
 143

143

Copyright Materials

 144

144



145