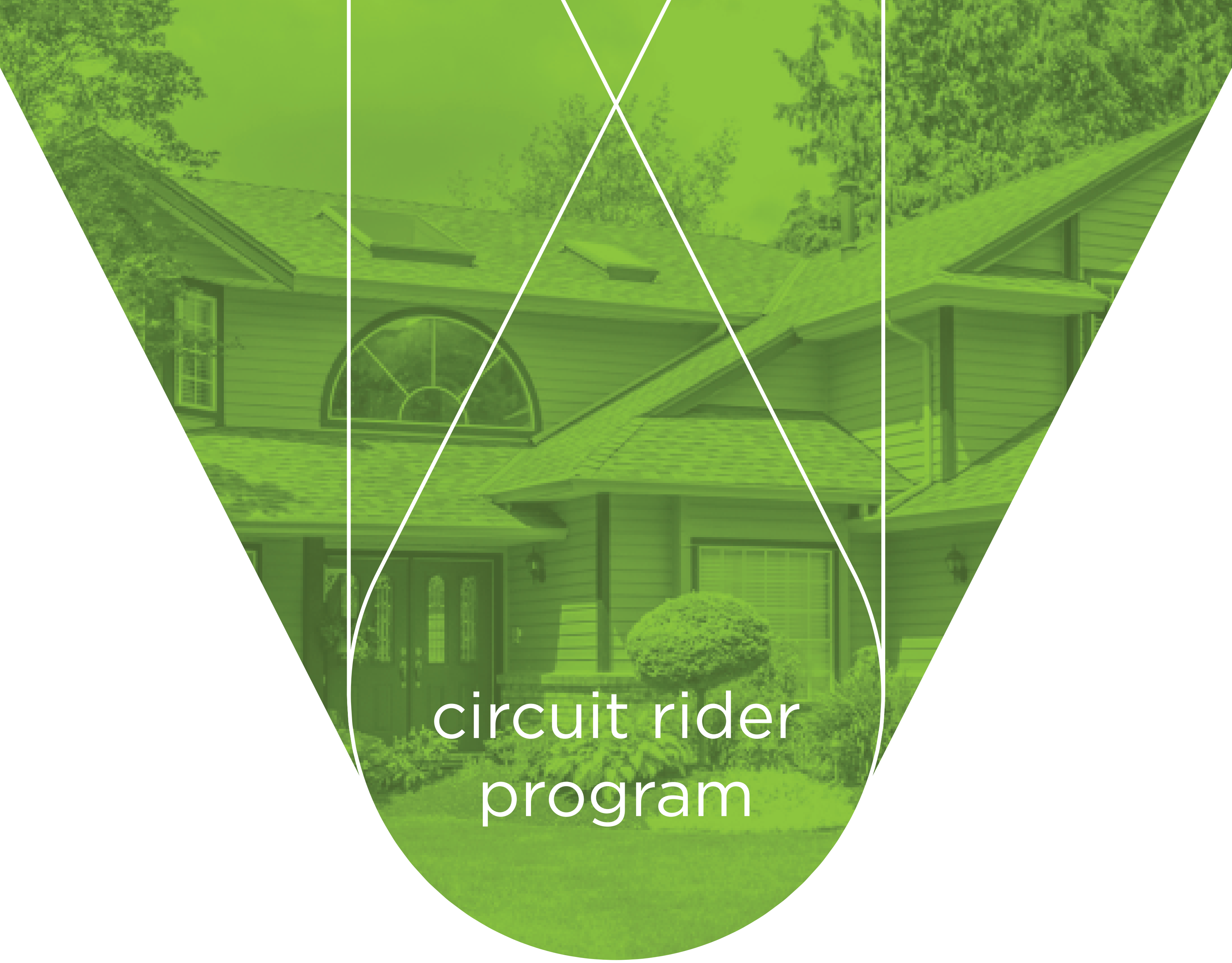

circuit rider program

YOUR RESOURCE GUIDE TO THE 2015 VIRGINIA RESIDENTIAL ENERGY CODE

VIRGINIA DHCD

viridiant

SEEA
SOUTHEAST ENERGY EFFICIENCY ALLIANCE

Your Resource Guide to the 2015 Virginia Residential Energy Code

On behalf of Viridiant, the Virginia Department of Housing and Community Development and the Southeast Energy Efficiency Alliance, we are pleased to distribute the following resources available as part of the Circuit Rider Program to aid in the Virginia Residential Energy Code implementation.

Thank you to the following jurisdictions for their participation in the Circuit Rider Program: City of Alexandria, Fairfax County, City of Franklin/Southampton, Goochland County, City of Hampton, James City County, Montgomery County, City of Norfolk, City of Suffolk, and Warren County. Their unique perspectives were crucial in compiling information to guide resource development.

- Manual J, D & S Brochures
- Understanding and Using the HVAC Design Review Form
- HVAC Installation Tips for Meeting Virginia Residential Energy Code
- Understanding Select Fields on the Residential Plans Examiner Review Form for HVAC System Design
- Recommended Practices for Remote Virtual Inspections
- Insulation Installation Tips for Meeting Virginia Residential Energy Code
- Lighting Tips for Meeting Virginia Residential Energy Code
- Virginia Energy Code Insulation Tech Tips
- Duct Sealing and Testing Inspection Guide
- Duct Test Report Form
- Duct Blaster Test Training Video*
- Indoor Air Quality, Code and COVID Guide
- Insulation, Air Barrier & Air Sealing Inspection Checklist
- Insulation & Air Barrier Guide
- Whole-House Fresh Air Ventilation Guide
- Slab Edge Insulation Guide
- Suggested Website Layout for Easy Navigating*
- Jack A. Proctor Virginia Building Code Academy*

As some resources can only be accessed digitally (denoted with an *), please visit www.viridiant.org/virginia-residential-energy-code-resources/ or scan the QR code on the back of this binder with your phone.

These resources are intended to support and provide deeper context and understanding of the implementation of the 2015 Virginia Residential Energy Code (Energy Code). Should there be a conflict between these resources and the Energy Code, the Energy Code takes precedence. These resources and tools are for training purposes only and DHCD is not intending to endorse and/or promote one product over another.

For more information or questions, please contact Viridiant at admin@viridiant.org or 804.225.9843.

Acknowledgment: *This material is based upon work supported by the Southeast Energy Efficiency Alliance and the Department of Energy under Award Number* DE-EE0003575*.*

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HVAC

manual J

ACCA

Air Conditioning
Contractors of America

2800 Shirlington Road
Suite 300
Arlington, VA 22206
Web Address: www.acca.org

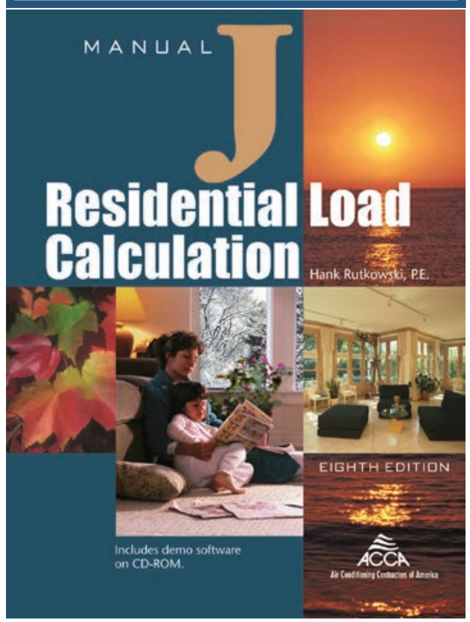
The Air Conditioning Contractors of America (ACCA) is dedicated to excellence in the heating, ventilation, air conditioning and refrigeration (HVACR) industry. As the largest HVACR contractor organization, ACCA is committed to helping its members succeed. Some of the fundamental ways in which our efforts are seen, are in the technical resources and industry standards, that guarantee quality HVACR design, installation and maintenance.

Sponsored by the ACCA Code Committee

The ACCA Code Committee was formed to address code issues and in particular, *to advise and assist ACCA in beneficially representing the contractors in the code processes that affect the HVACR industry.* This information has been provided for entities, seeking to verify that load calculations for an HVACR application have been correctly performed. For more information, contact:

Surumi Hudacsko
Phone: 703-824-8847
Fax: 703-575-9147

Verifying ACCA Manual J® Procedures



Includes load calculation checklist

ACCA
AIR CONDITIONING CONTRACTORS OF AMERICA

WHY ARE HEAT LOSS AND HEAT GAIN CALCULATIONS IMPORTANT

Achieving occupant satisfaction is the principal goal of any HVAC design. Primary factors impacting occupant satisfaction include: filtration, temperature and humidity control, air motion in the room, adequate ventilation, interior zoning needs and energy efficient operation. Occupant satisfaction is maximized when the heating and cooling system and equipment are the correct type and size and the air distribution system is properly designed and installed.

For residential applications, ACCA's Manual J, Eighth Edition (MJ8™) is the only procedure recognized by the American National Standards Institute (ANSI) and specifically required by residential building codes. Methods not based on actual construction details, nor founded on relevant physical laws and engineering principles, are unlikely to result in correct equipment sizing.

PROBLEMS WITH OVERSIZED EQUIPMENT

Oversized equipment results in marginal part load temperature control. While the temperature control at the thermostat may be satisfactory, equipment cycling may cause noticeable temperature swings in other rooms and larger temperature differences between rooms. Oversized equipment may cause degraded humidity control and increase the potential for mold growth, allergic reactions and respiratory problems. In these unfavorable conditions, occupants may experience additional discomfort and dissatisfaction. Other negative effects are higher installed costs, increased operating expenses, and increased maintenance costs. Furthermore, oversized equipment generally requires larger ducts, poses additional requirements on the power grid and may lead to more service calls.

REASONS FOR OVERSIZED EQUIPMENT

Three main reasons for oversized equipment are: (1) a guess is made on the load; (2) mistakes are made in the load calculation; (3) the equipment is selected for either unusual/extreme conditions such as abnormal temperatures or unusual occupancy loads (i.e. gatherings/parties). Other reasons include the use of inappropriate and inadequate "rules of thumb" such as '500ft^2/ton', '400CFM/ton', or 'total cooling capacity = 1.3 x sensible cooling capacity'. Furthermore, seemingly trivial mistakes such as ignoring building efficiency upgrades and assuming that the original design and installation are correct, all contribute towards inappropriate equipment sizing.

MANUAL J® VERIFICATION

While it is not practical to verify every aspect of a submitted MJ8 calculation, it is a good practice to review key elements that indicate general integrity of the calculations i.e. the contractor has made a good faith effort to provide reasonably accurate loads.

ITEMS TO VERIFY

The key load elements, grouped in roughly decreasing levels of impact on the overall contribution to the loads, are:

IMPACT ON LOAD	
HIGH	✓ Design Temperatures (Indoor and Outdoor) ✓ Windows, Glass Doors and Large Skylights (shading, overhangs, etc.) ✓ Ducts (location, leakage and duct wall R-values) ✓ Ceilings under an attic (R-values, roof material, roof color)
MEDIUM	✓ Small Skylights ✓ Infiltration ✓ Ventilation
LOW	✓ Appropriately Insulated Floors ✓ Appropriately Insulated Walls ✓ Internal Gains

It is also worth noting some unusual items that also contribute to the load. These include:

- Hot Tubs
- Whirlpool Tubs
- Three-season Porches

A NOTE ON UNDERSTANDING THE DESIGN PROCESS

Manual J allows contractors to perform a load calculation on a residential building/home. Apart from the load calculation being performed, the ducts must be sized and the correct size equipment must be selected. ANSI-recognized ACCA Manual D® for duct sizing and ACCA Manual S® for residential equipment selection provide guidance here.

The order of this checklist follows Form J1 of ACCA Manual J8®.

#	Key Item	Check	Questions to Ask	Circle Answer*		
1	Design Temperatures	✓ Indoor Design Temperatures	Is the indoor design temperature for *Heating*: per Local Code OR 70°F (21°C) at 30% RH?	YES	NO	-----
			Is the indoor design temperature for *Cooling*: per Local Code OR 75°F (24°C) at 50% RH? [or 55% for humid climate, 45% for dry climate?]	YES	NO	-----
		✓ Outdoor Design Temperatures	Is the outdoor design temperature per Table 1 of MJ8 or Local Code?	YES	NO	-----
2	Windows & Glass Doors	✓ U-values and SHGC values	Are the SHGC and U-values reasonable for the window types and frame constructions? (see Table 2 of MJ8)	YES	NO	-----
		✓ Shading Adjustments	Have window shading (curtains, drapes, insect screens, tinting, etc.) adjustments been made?	YES	NO	-----
		✓ Overhang Adjustments	Have roof overhang adjustments been made?	YES	NO	-----
		✓ Total Area	Is the total area for the windows & glass doors roughly equal to the area shown on the drawing plans?	YES	NO	-----
		✓ Exposure Directions	Do the exposure directions [North (N), North-East (NE), etc.] appear correct?	YES	NO	-----
3	Skylights	✓ U-values and SHGC values	Are the SHGC and U-values appropriate for the skylight types and frame constructions? (see Table 2 of MJ8)	YES	NO	N/A
		✓ Shading Adjustments	Have adjustments been made for drapes, tinting and reflective coatings?	YES	NO	N/A
		✓ Total Area	Is the total area for the skylights roughly equal to the area shown on the drawing plans?	YES	NO	N/A
		✓ Exposure Directions	Do the exposure directions [North (N), North-East (NE), etc.] appear correct?	YES	NO	N/A
4	Doors | Wood, Metal	✓ *None*	--	-----	-----	-----
5	Walls | Above Grade, Below Grade	✓ Insulation	Are correct wall insulation R-values taken into account when the wall loads are calculated?	YES	NO	-----
		✓ Total Area	Is the total area for the walls equal to the area shown on the drawing plans?	YES	NO	-----
6	Ceilings	✓ Insulation	Is correct ceiling insulation R-value taken into account when the ceiling load is calculated?	YES	NO	N/A
		✓ Radiant Barrier	If applicable, does the load calculation take credit for a radiant barrier?	YES	NO	N/A
		✓ Roof color and material	Is correct roof color and material taken into account when the ceiling load is calculated?	YES	NO	-----
		✓ Total Area	Is the total area for the ceilings equal to the area shown on the drawing plans?	YES	NO	-----
7	Floors	✓ Insulation	Is the floor insulation and type of construction representative of what is built/planned?	YES	NO	-----
8	Infiltration	✓ Envelope Tightness	Is the listed envelope tightness (tight, semi-tight, average, semi-loose, loose) appropriate?	YES	NO	-----
		✓ Above grade volume	Is the total above grade volume equal to what is shown on the drawing plans?	YES	NO	-----
9	Internal Gains	✓ Appliances	Are the appliance gains 1200 Btuh, 2400 Btuh or a value recommended by MJ8?	YES	NO	-----
		✓ Occupants	*Is Maximum Number of Occupants = Number of Bedrooms + 1?*	YES	NO	-----
			- Is Btuh (sensible) = 230 x Number of Occupants? - Is Btuh (latent) = 200 x Number of Occupants?	YES	NO	-----
10	Ducts	✓ Duct Location	If located in an unconditioned space, are the ducts insulated (appropriate R-value)?	YES	NO	N/A
		✓ Duct Tightness	Is the duct tightness category 'average sealed' or higher (i.e. notably sealed, extremely sealed)?	YES	NO	-----
11	Ventilation	✓ Intermittent Fans	Are intermittent bathroom and kitchen fans excluded from the infiltration calculations?	YES	NO	N/A
		✓ Continuous Exhaust Fans	Are dedicated exhaust fans (continuous) included in the calculations?	YES	NO	N/A
		✓ Heat Recovery Equipment	Are the heat recovery equipment and/or a ventilating dehumidifier included in the calculations (if applicable)?	YES	NO	N/A

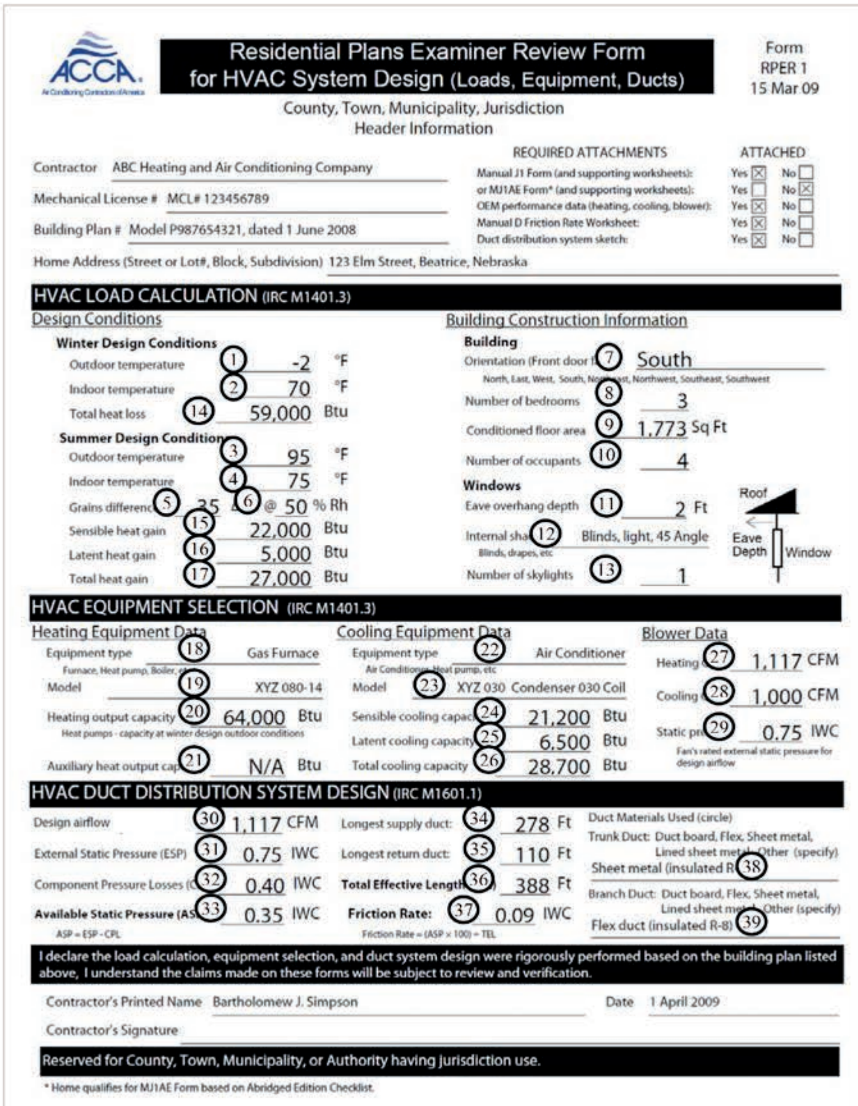
*Questions should be answered 'YES' (where applicable) to achieve representative load calculations.

hvac design review

Understanding and Using the HVAC Design review Form

Each of the 39 points of requested information is discussed, and references to the supporting manual are given to substantiate the requirement.

Table of Contents



Residential Plans Examiner Review Form for HVAC System Design (Loads, Equipment, Ducts)

Form RPER 1 15 Mar 09

County, Town, Municipality, Jurisdiction

Header Information

Contractor: ABC Heating and Air Conditioning Company

Mechanical License #: MCL# 123456789

Building Plan #: Model P987654321, dated 1 June 2008

Home Address (Street or Lot#, Block, Subdivision): 123 Elm Street, Beatrice, Nebraska

REQUIRED ATTACHMENTS	ATTACHED
Manual J1 Form (and supporting worksheets):	Yes [X] No [ ]
or MJ1AE Form* (and supporting worksheets):	Yes [ ] No [X]
OEM performance data (heating, cooling, blower):	Yes [X] No [ ]
Manual D Friction Rate Worksheet:	Yes [X] No [ ]
Duct distribution system sketch:	Yes [X] No [ ]

HVAC LOAD CALCULATION (IRC M1401.3)

Design Conditions

Winter Design Conditions
- Outdoor temperature (1) -2 °F
- Indoor temperature (2) 70 °F
- Total heat loss (14) 59,000 Btu

Summer Design Conditions
- Outdoor temperature (3) 95 °F
- Indoor temperature (4) 75 °F
- Grains difference (5) 35 (6) @ 50 % Rh
- Sensible heat gain (15) 22,000 Btu
- Latent heat gain (16) 5,000 Btu
- Total heat gain (17) 27,000 Btu

Building Construction Information

Building
- Orientation (Front door faces) (7) South — North, East, West, South, Northeast, Northwest, Southeast, Southwest
- Number of bedrooms (8) 3
- Conditioned floor area (9) 1,773 Sq Ft
- Number of occupants (10) 4

Windows
- Eave overhang depth (11) 2 Ft
- Internal shade (12) Blinds, light, 45 Angle — Blinds, drapes, etc
- Number of skylights (13) 1

Roof / Eave Depth / Window

HVAC EQUIPMENT SELECTION (IRC M1401.3)

Heating Equipment Data
- Equipment type (18) Gas Furnace — Furnace, Heat pump, Boiler, etc
- Model (19) XYZ 080-14
- Heating output capacity (20) 64,000 Btu — Heat pumps - capacity at winter design outdoor conditions
- Auxiliary heat output capacity (21) N/A Btu

Cooling Equipment Data
- Equipment type (22) Air Conditioner — Air Conditioner, Heat pump, etc
- Model (23) XYZ 030 Condenser 030 Coil
- Sensible cooling capacity (24) 21,200 Btu
- Latent cooling capacity (25) 6,500 Btu
- Total cooling capacity (26) 28,700 Btu

Blower Data
- Heating (27) 1,117 CFM
- Cooling (28) 1,000 CFM
- Static pressure (29) 0.75 IWC — Fan's rated external static pressure for design airflow

HVAC DUCT DISTRIBUTION SYSTEM DESIGN (IRC M1601.1)

- Design airflow (30) 1,117 CFM
- External Static Pressure (ESP) (31) 0.75 IWC
- Component Pressure Losses (CPL) (32) 0.40 IWC
- **Available Static Pressure (ASP)** (33) 0.35 IWC — ASP = ESP - CPL
- Longest supply duct: (34) 278 Ft
- Longest return duct: (35) 110 Ft
- **Total Effective Length (TEL)** (36) 388 Ft
- **Friction Rate:** (37) 0.09 IWC — Friction Rate = (ASP × 100) ÷ TEL

Duct Materials Used (circle)

Trunk Duct: Duct board, Flex, Sheet metal, Lined sheet metal, Other (specify)
Sheet metal (insulated R (38)

Branch Duct: Duct board, Flex, Sheet metal, Lined sheet metal, Other (specify)
Flex duct (insulated R-8) (39)

I declare the load calculation, equipment selection, and duct system design were rigorously performed based on the building plan listed above, I understand the claims made on these forms will be subject to review and verification.

Contractor's Printed Name: Bartholomew J. Simpson   Date: 1 April 2009

Contractor's Signature:

Reserved for County, Town, Municipality, or Authority having jurisdiction use.

* Home qualifies for MJ1AE Form based on Abridged Edition Checklist.

UNDERSTANDING AND USING THE HVAC DESIGN REVIEW FORM

SECTION I: HVAC LOAD CALCULATION:

The purpose of this portion of the form is to ensure that the objective, prescribed, and representative values from the buildings plans/drawings were used in the Manual J load calculation[1].

1. Winter OD Temp: Ensure this value comes from MJ8 Table 1A or 1B. Manual J8 §A5-1: "Use of this set of conditions (from Table 1A or 1B) is mandatory, unless a code or regulation specifies another set of conditions." See Figure 1 below, the Winter OD Temperature is -2°F.

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)
Nebraska									
Beatrice	1323	40	-2	95	74	28	35	41	M

Figure 1: Table 1A of Manual J

2. Winter Indoor temperature: 70°F. Manual J8 §A5-3: "Heating and cooling load estimates shall be based on the indoor design conditions listed below. Use of this set of conditions is mandatory, unless superseded by a code, regulation, or documented health requirement." See Figure 2: Indoor Design Conditions.

Indoor Design Condition Manual J §A5-3	Stated Value
Heating indoor dry bulb temperature	70°F
Cooling indoor dry bulb temperature	75°F

Figure 2: Indoor Design Conditions

3. Summer OD Temp: See #1. In Figure 1 above, the Summer OD Temperature is 95°F.
4. Summer Indoor temperature: 75°F. See #2 and Figure 2.
5. Summer Design Grains: See #1. In Figure 1 above, the Summer Design Grains are 35 at 50% RH.
6. Relative Humidity: Design Grains correspond to an RH (Relative Humidity). In Figure 1 above, the Summer Design Grains were selected at 50% RH. The HVAC system designer has the discretion to select either the 55%, 50%, or 45% value for this design element. Code Officials may wish to refer to IECC Figure 301.1 Climate Zones.

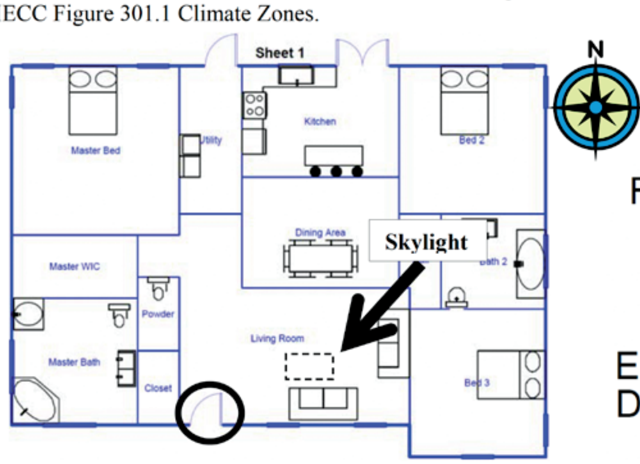


Figure 3: Example Home

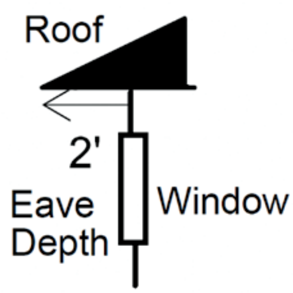


Figure 4: Window

[1] The abridged procedure may be used to estimate a homes heating and cooling requirements, but the home must meet certain criteria. These criteria are listed on the page 13.

7. Orientation (e.g., North, South…): Verify the orientation of the home's windows/doors/skylights correspond to the orientation of the plan. Manual J8 §A5-4 Plans, Sketches, and Notes states, "Sketches and notes shall provide the following information. Sketches based on plan take-off or field observation: An arrow or directional rosette that points north." Using Figure 3 as an example, the front door (in the living room) should be listed as facing South. The cooling loads for windows and skylights are very dependent on direction; evaluate some windows to see if their direction corresponds to that of the front door.
8. Number of Bedrooms: Verify the number of bedrooms match the plan. Using Figure 3 as an example, the number of bedrooms should equal 3.
9. Floor area: Ensure floor area listed is approximate to home's floor plan.
10. Occupants: Ensure this value equals the number of bedrooms plus one. Manual J8: §3.11, Occupants produce sensible and latent loads. The number of occupants shall equal the number of bedrooms plus one. Using Figure 3 as an example, the number of occupants should equal 4.
11. Windows Overhang: This value shall represent the largest overhang. Multiple overhang depths may be on the plans, ensure the deepest overhang value is recorded. Manual J8: §2-3 (Manual J Do's – Mandatory Requirements) item 6: …overhang adjustments shall be applied to all windows and glass doors, including purpose-built day-lighting windows. Figure 4 illustrates a window overhang depth of two feet.
12. Windows Internal Shade: For an *existing* home this describes the predominate type of internal shading, in a *new* home it describes the *projected* shading that will be predominate. Manual J8: §2-3 (Manual J Do's – Mandatory Requirements) item 7: "Take credit for internal shade (the default is a medium color blind with slats at 45 degrees, or use the actual device – this applies to all vertical glass – this does not apply to purpose-built day-light windows)." HVAC system designers should default to a medium color blind with slats at 45 degrees.

Figure 5: Example of Internal Window Shading

13. Skylights (Number): Skylights can have a large impact on the heating and cooling load calculations. Simply ensure the number of skylights on the building plan is represented accurately, Figure 3 has one skylight in the Living Room.
14. Total Heat Loss: This value is used to select the heating system, a code official may wish to verify the total represents the sum of the individual loads.
15. Sensible Heat Gain: This value represents the amount of dry heat the cooling system must remove.
16. Latent Heat Gain: This value represents the amount of moist heat the cooling system must remove.
17. Total Heat Gain: This value is used to size cooling systems; the total cooling capacity shall equal the sensible and latent heat gains.

Understanding and Using the HVAC Design review Form

Section II: HVAC Equipment Selection:

The purpose of this portion of the form is to ensure the equipment selected meets the heating or cooling requirements calculated in Section I for the home. Ensure the HVAC designer used the manufacturer's performance data, and did not exceed the limits prescribed by the recognized national standard.

Equipment sizing requirements (2009 IRC, Section M1401.3) from Manual S:

Manual S Equipment Selection Sizing Limitations		
Equipment	Sizing Limits	Reference
Furnaces	100% - 140% of total heating load	Section 2-2
Boilers	100% - 140% of total heating load	Section 2-2
Air conditioners	115% of total cooling load*	Section 3-4
Heat pumps (cooling dominant climates)	115% of total cooling load*	Section 4-4
Heat pumps (heating dominant climates)	125% of total cooling load*	Section 4-4
Supplemental heat (heat pumps)		
• Electric	Based on equipment balance point	Section 4-8
• Dual fuel	100% - 140% of total heating load	Section 6-8
Emergency Heat (heat pumps)	Based on local codes	Section 4-9
Manual S Input for Design Air Flow (Manual D)		
• Heating	Temperature rise requirement	Section 2-6
• Cooling	Air flow associated with the selected equipment's capacity	Section 3-11
* The size of the cooling equipment must be based on the same temperature and humidity conditions that were used to calculate the Manual J loads.		

Figure 6: Manual S Sizing Limitations

Heating Equipment Data

18. Equipment Type: A description of the type of heat source used: furnace, boiler. If a heat pump is used list the fan coil/air handler and supplemental heater size.
19. Model: The model of heater that will be installed. In Figure 7, the model is a 080-14.
20. Heating output capacity: The amount of maximum OUTPUT heating capacity available from the heater shall be equal to, but not exceed 140% of the heat loss (value from item #14); in Figure 7 the output capacity is 64,000 Btu/h. Manual S §2-2 states, "…the output capacity of the furnace or boiler must be greater than the design heating load, but no more than 40 percent larger than the design heating load." Manual S further states in §2-3, "Always use the output capacity value to size the heating equipment."

XYZ Furnace Company

MODEL	060 - 14	080 - 14	080 - 16
TYPE	Downflow / Horizontal	Downflow / Horizontal	Downflow / Horizontal
RATINGS			
Input BTUH	60,000	80,000	80,000
Capacity BTUH (ICS)	48,000	64,000	64,000
AFUE	80.0	80.0	80.0
Temp. rise (Min.-Max.) °F.	30 - 60	35 - 65	35 - 65

Figure 7: Example Heating Performance Data

a. Multi-Stage equipment: Heaters (furnaces, boilers, etc.) may have more than one capacity level. The maximum heater capacity shall not exceed the heat loss (item #14) by more than 40%. For example, this home has a heat loss of 59,000, the HVAC contractor could install a two stage furnace with a high fire output capacity of 73,000Btu, see Figure 8, and meet the sizing limit. However, a furnace with a low fire output capacity were 60,000Btu and the high fire output capacity were 93,000Btu, see Figure 8, would exceed the home's heating needs by more than 40%.

XYZ Furnace Company - 2 Stage Furnace

MODEL	060 - 14	080 - 16	100 - 16	120 - 18
RATINGS				
1st Stage Input BTUH	39000	52000	65000	72000
1st Stage Capacity BTUH (ICS)	36000	48000	60000	66600
2nd Stage Input BTUH	60000	80000	100000	120000
2nd Stage Capacity BTUH (ICS)	56000	73000	93000	112000
AFUE (ICS)	93.0	92.5	93.0	92.5
Temp. Rise (Min.-Max.) °F.	30 - 60	35 - 65	35 - 65	40 - 70

Figure 8: Example of 2 Stage Furnace Performance Data

b. Heat pumps are different; the equipment's heating capacity diminishes as the outdoor temperature gets colder. Heat pumps usually lack the capacity to meet the total heating requirement at the design outdoor temperature used in the heat loss calculations (item #1). Therefore, for heat pumps this value shall be the heat pump's heating capacity at the winter OD temperature.

As an alternate example, the heat pump in Figure 9 can provide 10,700 Btu/h at an OD temperature of 12°F. The capacity of the supplemental heat source will be discussed next. For further illustration, see www.acca.org/codes/reviewform, Example #2.

XYZ 030 Heating Performance Data

O.D. TEMP. F.	HEATING CAPACITY MBH AT INDOOR DRY BULB TEMP. 70	75	80	TOTAL POWER IN KILOWATTS AT INDOOR DRY BULB TEMP. 70	75	80
2	7.7	7.6	7.6	1.39	1.43	1.47
7	9.2	9.1	9.0	1.42	1.47	1.51
12	10.7	10.5	10.5	1.46	1.50	1.55
17	12.1	12.0	11.9	1.50	1.54	1.59
22	13.3	13.1	13.0	1.54	1.58	1.63
27	14.4	14.2	14.1	1.57	1.62	1.67
32	15.5	15.4	15.2	1.61	1.66	1.71
37	17.0	16.8	16.7	1.65	1.70	1.75
42	19.0	18.8	18.6	1.68	1.73	1.78
47	21.0	20.8	20.6	1.71	1.76	1.81
52	22.5	22.3	22.1	1.75	1.80	1.85
57	24.0	23.7	23.5	1.78	1.83	1.89
62	25.4	25.2	24.9	1.82	1.87	1.93
67	26.9	26.6	26.4	1.85	1.91	1.96
72	28.4	28.1	27.8	1.89	1.94	2.00

CORRECTION FACTORS FOR OTHER AIRFLOWS (MULTIPLY DATA BY FACTOR)

	AIRFLOW	TOTAL CAPACITY	SENSIBLE CAPACITY
LOW	700	0.98	0.97
HIGH	900	1.01	1.02

Figure 9: Example: Heat Pump - Heating Performance Data

21. Supplemental heating output capacity: The auxiliary heat source that supplements the heat pump, see 20.b. above. Manual S §4-8 states that the supplemental heat is based on, "…the difference between the winter design heating load and the capacity the heat pump will have when it operates at the winter design temperature." Therefore, when auxiliary heat is used, it shall be based on the difference between the homes heat loss (line #14) and the heat pump's capacity (line #20).

    Supplemental heat may also be required by code for circumstances when the heat pump has failed, for example if the compressor in the heat pump fails, then the emergency heat would provide some heating. Manual S states in §4-8 that emergency heat sizing shall be in compliance with local codes.

Cooling Equipment Data (performance data from the equipment manufacturer)

22. Equipment Type: A description of the cooling equipment that will be installed: air conditioner, heat pump, etc.
23. Model: The model of cooling equipment that will be installed. In Figure 11, the model is an AC -030.
24. Sensible cooling capacity: The sensible cooling capacity of the equipment should satisfy the sensible cooling requirement (line #15). If the sensible capacity is insufficient, Manual S §3-10 (Step 4) states that the HVAC system designer is permitted to, "Add half of the *excess* latent capacity to the sensible capacity…"
25. Latent cooling capacity: Latent capacity is rarely listed in the manufacturers' performance data. However, it can be derived by subtracting the sensible from the total cooling capacities. The latent cooling capacity is crucial to proper health and safety. When the cooling equipment lacks the latent capacity, moisture related problems arise: affects to framing, growth of harmful compounds, and organisms.
26. Total cooling capacity: The amount of maximum cooling capacity available from the equipment shall not exceed 115% of the heat gain (value from Line #17). The air conditioner in Figure 11 has a total cooling capacity of 28,700 Btu/h. Manual S §3-4 states,:
    a. "Cooling equipment shall be sized so that the total cooling capacity does not exceed the total cooling load by more than 15 percent."
    b. "…heat pump equipment (air source or water source) is installed in a warm or moderate climate, the total cooling capacity shall not exceed the total cooling load by more than 15 percent."
    c. "…heat pump equipment (air source or water source) is installed in a cold climate (where heating costs are a primary concern), the total cooling capacity can exceed the total cooling load by 25 percent."

    Each equipment manufacturer presents their expanded performance data in a unique manner. Figure 11 is one example of the expanded performance data from a fictitious original equipment manufacturer (OEM). In this example, the Total cooling capacity is 28,700 Btu/h. The key elements considered are:

Key Element	Information Source
Outdoor drybulb temperature	This value shall be within 5°F of the Summer OD design temperature (item #3)
Indoor wet bulb (I.D. W.B) temperature	75°F @ 45% RH ≈ 62°F WB 75°F @ 50% RH ≈ 63°F WB 75°F @ 55% RH ≈ 64°F WB
Indoor dry bulb temperature	This shall match the indoor design temperature in cell on the front of the form
CFM	The airflow required to achieve this capacity. This value is used on item # 28.

Figure 10: Information for Manufacturer's Cooling Performance Data

XYZ Performance Data						
Model 030 with Coil AC030 and Furnace FR 080-14 @ 1,000 CFM						
OD Dry Bulb (F)	Indoor Entering Wet Bulb (F)	Total Capacity	Sensible Capacity at Entering Dry Bulb Temperature (F)			
			72	75	78	80
85	59	28,400	22,600	25,300	27,800	29,400
	63	29,900	18,800	21,600	24,300	26,100
	67	32,100	15,100	17,900	20,700	22,600
	71	34,700	11,400	14,200	17,000	18,900
95	59	27,300	22,200	24,900	27,400	28,300
	63	28,700	18,500	21,200	23,900	25,700
	67	30,800	14,700	17,500	20,400	22,200
	71	33,300	11,000	13,700	16,600	18,500
105	59	26,200	21,900	24,500	27,100	27,200
	63	27,600	18,100	20,900	23,600	25,400
	67	29,700	14,300	17,200	20,000	21,800
	71	32,100	10,600	13,300	16,200	18,100

OD Dry Bulb – Outdoor Dry Bulb, the outdoor temperature.

Correction Factors for other Airflows			
	Airflow	Total Capacity	Sensible Capacity
Low	875	0.98	0.93
High	1125	1.02	1.06
Multiply rated capacity data by factor.			

Figure 11: Sample I Equipment Performance Data

A similar unit from a different manufacturer, uses the same basic information is presented another way, with different cooling capacities.

ABC Air Conditioners – Detailed Cooling Capacities Model AC-30 with Coil AC-030							
Evaporator Air		Condenser Entering Air Temp – DB (F)					
CFM	EWB (F)	85		95		105	
		Capacity		Capacity		Capacity	
		Total	Sensible	Total	Sensible	Total	Sensible
875	72	34,610	18,190	33,100	17,620	31,520	17,020
	67	31,400	22,240	30,000	21,650	28,520	21,040
	63	28,620	26,290	27,350	25,680	26,020	25,040
	57	27,840	27,840	26,820	26,820	25,740	25,740
1000	72	35,250	19,090	33,680	18,500	32,030	17,890
	67	31,990	23,660	30,530	23,060	29,000	22,440
	63	29,300	27,220	28,020	26,560	26,770	26,770
	57	29,020	29,020	27,930	27,930	26,780	26,780
1125	72	35,720	19,920	34,110	19,330	32,410	18,710
	67	32,430	25,010	30,930	24,410	29,360	23,780
	63	29,970	29,970	28,850	28,850	27,630	27,630
	57	30,000	30,000	28,850	28,850	27,640	27,640

Figure 12: Sample II Equipment Performance Data

Some cooling equipment is available with two speeds or stages, other cooling equipment can scale its capacity to meet peak and part-load conditions. These types of cooling equipment, generally, are produced in limited sizes. Due to the sizing limitations, in these circumstances, the designer should choose the smallest equipment that will meet the total cooling load. For example, this home has a cooling load of 27,000. Figure 13 shows the available units, from these, the 3 ton A/C unit should be chosen because it is the smallest unit that can meet the total cooling load.

2 Ton A/C Unit		3 Ton A/C Unit		4 Ton A/C Unit	
1st Stage	2nd Stage	1st Stage	2nd Stage	1st Stage	2nd Stage
12,000	24,000	18,000	36,000	24,000	48,000

Figure 13: Example Two Stage Equipment Selection

Blower Data:

27. Heating CFM: The volume of air required to deliver the heating Btu for the home.

   a. Furnaces: The airflow calculated from the heating capacity and temperature range required by the manufacturer. The XYZ 80-14 and -16 (Figures 7 & 8) must have a temperature difference (TD) of no less than 35°F, and no more than 65°F. The airflow formula is CFM = Btuh ÷ (TD × 1.08 × ACF) where:

      CFM: Cubic Feet per Minute, the volume of air moving through the equipment
      Btu/h: The heating capacity of the furnace or other heat source.
      TD: Temperature Difference, e.g., the difference between 35°F and 65°F[2].
      1.08: A physics constant that converts the weight of air into a volume of air.
      ACF: Altitude Correction Factor, for homes at elevations above 1,000 feet.

      In this example, the airflow is CFM = 64,000Btuh ÷ (50°F × 1.08 × 1.0) = 1,185 CFM

   b. Heat pumps: The air flow associated with the heating capacity for the equipment selected. If Figures 11 and 12 were performance data for a heat pump, the heating and cooling airflow would be 1,000 CFM. Ensure you read and apply any footnotes added by the OEM. In addition, this airflow must also meet the supplemental heater's requirements.

28. Cooling CFM: The air flow associated with the total cooling capacity for the equipment selected in Figures 11 and 12 the airflow is 1,000 CFM.

Adjusting Design Airflow: For forced air systems, the HVAC system designer must carefully evaluate blower assembly performance in the selected equipment, e.g., furnace, air handler, fan coil, etc. In this example, the design *heating* airflow is 1,185 CFM; the design *cooling* airflow is 1,000 CFM. Evaluating the furnace in Figure 14, the designer determines that on Med-Low fan speed, the blower assembly can deliver about 1,117 CFM, and on Low fan speed 1,000 CFM. Both airflows are at the same external static pressure (ESP, see item #29). The HVAC system can be designed at this common ESP, and the equipment's fan speed can be set on Med-Low for heating, and Low for cooling.

However, before the designer may alter the heating CFM, they must ensure the TD through the equipment remains within the boundaries set by the OEM. 1,117 CFM will provide a TD of 53°F. The TD formula is TD = Btu/h ÷ (CFM × 1.08 × ACF) where:

TD: Temperature Difference the design airflow should achieve.
Btu/h: The heating capacity of the furnace or other heat source.
CFM: Cubic Feet per Minute, the volume of air moved by the blower
1.08: A physics constant that converts the weight of air into a volume of air.
ACF: Altitude Correction Factor, for homes at elevations above 1,000 feet.

In this example, the TD = 64,000Btuh ÷ (1,117CFM × 1.08 × 1.0) = 53°F. A 53°F temperature difference falls safely within the range of 35°F to 65°F.

---

[2] Any temperature between 35°F and 65°F would be acceptable to the OEM. However, a low TD promotes condensation damage and a high TD can decreases the heat exchanger life cycle. To find the middle ground (50°F), take the difference between 35°F and 65°F, which is 30°F. Half of 30°F is 15°F. 30°F + 15°F = 50°F or another way is 65°F - 15°F = 50°F.

29. Static Pressure: The design static pressure from the air moving equipment's blower performance table. The static pressure is the amount of pressure in inches water column (IWC) the blower can "push" against and still deliver the stated volume of air. For example, in Figure14, on Med-Low fan speed the FR 80-14 furnace can push 1,117 CFM (interpolated[3] between 1,140 CFM and 1,095 CFM) against a constant or "static" pressure of 0.75 (interpolated between 0.7 and 0.8). This value should not be confused with the Friction Rate which will be discussed later.

XYZ Furnace Company Blower Data										
Air Delivery – CFM (with filter)										
Unit Size	Return Air Entry	Fan Speed	External Static Pressure (inches water column)							
			0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8
FR 060-14	1 side or bottom	High	1100	1065	1005	945	900	805	730	610
		Med-Low	890	865	810	765	705	620	540	475
		Low	745	710	670	625	565	505	425	360
FR 080-14	1 side or bottom	High	1740	1705	1660	1615	1570	1500	1425	1355
		Med-High	1500	1470	1445	1410	1375	1330	1280	1210
		Med-Low	1340	1315	1300	1270	1235	1200	1140	1095
		Low	1195	1175	1165	1130	1100	1070	1030	975
FR 080-16	1 side or bottom	High	2250	2175	2090	2020	1930	1855	1760	1670
		Med-High	2020	1950	1900	1840	1790	1710	1640	1545
		Med-Low	1725	1690	1660	1630	1575	1520	1460	1370
		Low	1490	1480	1460	1440	1380	1340	1295	1230
‡ • Airflow shown is for bottom only return-air supply with factory supplied 1-in. washable filter (0.05 IWC).										

Figure 14: Example Blower Performance Data

A similar unit from a different OEM, presents the same basic information in another format, with different static pressure values (note the special clarification of test conditions in both examples).

Airflow Performance ABC 080-036: Wet coil, No Heaters												
EXTERNAL STATIC PRESSURE (in.w.g.)	AIRFLOW (CFM)											
	VERTICAL						HORIZONTAL					
	230 VOLTS			208 VOLTS			230 VOLTS			208 VOLTS		
	HI	MED	LO	HI	MED	LO	HI	MED	LO	HI	MED	LO
0	[illegible]	[illegible]	1077	1402	1200	963	1402	1265	1069	1349	1165	947
0.1	[illegible]	[illegible]	1082	1352	1166	948	1350	1228	1048	1298	1131	915
0.2	[illegible]	[illegible]	1055	1292	1130	924	1289	1180	1015	1243	1090	890
0.3	[illegible]	[illegible]	1013	1227	1089	893	1225	1127	976	1185	1047	866
0.4	[illegible]	[illegible]	965	1163	1040	856	1163	1073	933	1127	1001	836
0.5	1139	1049	915	1098	982	814	1104	1019	887	1066	953	795
0.6	1065	987	862	1031	915	764	1043	962	835	1001	898	743
0.7	988	916	799	957	839	703	977	897	771	929	829	677
0.8	907	827	713	870	757	624	894	815	689	846	736	599
0.9	823	702	584	760	671	521	783	707	579	745	609	513
NOTES:	With filter, no horizontal drip tray Small apex baffle Subtract 0.06" W.G. for downflow						As shipped except without filter Subtract 0.05"" W.G. for horizontal left					

Figure 15: Sample Blower Performance Data

[3] Interpolation is the process of determining a value between two known, prescribed values.

UNDERSTANDING AND USING THE HVAC DESIGN REVIEW FORM

SECTION III: HVAC DUCT DISTRIBUTION SYSTEM DESIGN:

The purpose of this section is to ensure the air moving values and capabilities of the equipment selected in Section II are sufficient to meet the resistance offered by additional components and the duct distribution system. Ensure these values are accurately transcribed from the Manual D Friction Rate Worksheet.

30. Design airflow: The volume of air delivered by a piece of equipment at a given fan speed, voltage, and amount of pressure (the larger of Heating or Cooling CFM, item 27 or 28). When selecting a blower assembly, the design airflow will be the higher of the two, 1,117 CFM.
31. Equipment design ESP: This value shall match the value in item #29, for example, in Figure 14 the equipment design ESP is 0.75.
32. Component Pressure Losses (CPL): The total resistance or pressure created by accessories like filters, refrigeration coils, grilles, registers, dampers, and others. For example, in Figure 16 the component pressure loss is 0.40.
33. Available Static Pressure (ASP): The difference between the external static pressure (item 31) and the component pressure losses (item 32). This number represents the amount of resistance (or pressure) the ducts can create and still allow the fan to deliver the correct airflow. This is a major factor in determining the friction rate which will be used to size the ducts. For example, in Figure 16 the ASP is 0.35.

Step 1) Manufacturer's Blower Data

External static pressure (ESP) = 0.75 IWC   Cfm = 1,117

Step 2) Component Pressure Losses (CPL)

Direct expansion refrigerant coil	0.18
Electric resistance heating coil	
Hot water coil	
Heat exchanger	
Low efficiency filter	
High or mid-efficiency filter	0.13
Electronic filter	
Humidifier	
Supply outlet	0.03
Return grille	0.03
Balancing damper	0.03
UV lights or other device	
Total component losses (CPL)	0.40 IWC

Step 3) Available Static Pressure (ASP)

ASP = (ESP - CPL) = (0.75 - 0.40) = 0.35 IWC

Figure 16: Friction Rate Worksheet - Top Section

34. Longest SUPPLY duct: The "effective" length of the longest supply (conditioned air) duct run. Different duct fittings create different amounts of resistance, the resistance of a 90° elbow may be one foot long, but that elbow may offer as much resistance as thirty feet of straight pipe. A duct runout may look short, but because of elbows and other fittings it may actually have a long effective length. For example, in Figure 17 the supply side total effective length (TEL) is 278.

35. Longest RETURN duct: The same properties apply to return ducts (that bring room air back to the furnace, fan coil, or air handler). For example, in Figure 17 the return side TEL is 110.

36. Total Effective Length (TEL): The sum total of the supply and return effective lengths. In Figure 17 the total effective length is 388.

Step 4) Total Effective Length (TEL)

Supply-side TEL + Return-side TEL = (278 + 110) = 388 Feet

Step 5) Friction Rate Design Value (FR)

FR value from friction rate chart = 0.09 IWC/100

Figure 17: Friction Rate Worksheet - Mid Section

37. Friction Rate *(ASP x 100) ÷ TEL = FR]*: The value used to determine the size of duct required to carry a certain volume of air. It is important to ensure the FR is greater than 0.06 and less than 0.18 to control air velocity. If the FR is outside this boundary the contractor should justify their design. In Figure 18, the friction rate is 0.09. The FR is one value used to size the ducts; the other factor in duct sizing is the duct material.

Step 5) Friction Rate Design Value (FR)

FR value from friction rate chart = 0.09 IWC/100

$$FR = \frac{ASP \times 100}{TEL}$$

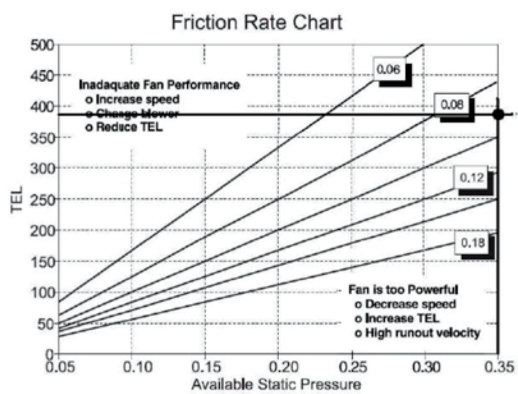


Figure 18: Friction Rate Worksheet - Bottom Section

Duct Materials Used:

38. Trunk duct: Ensure the planned materials are listed: Metal pipe, fiberglass duct board, flexible duct, or other. Use a friction chart or duct calculator (Figure 20) to verify the size of the ducts considering the friction rate and the duct material. Do not use a "sheet metal" duct calculator to size flexible ducts.

39. Branch duct: See item 38.

Examine Duct Distribution Sketch: Verify duct sizes with a duct calculator like the one in Figure 20, and ensure all isolated rooms (like bedrooms) have a low resistance air path (cross over duct / transfer grille) or a return duct. Ensure the duct calculator used has the appropriate scale for the duct material used.

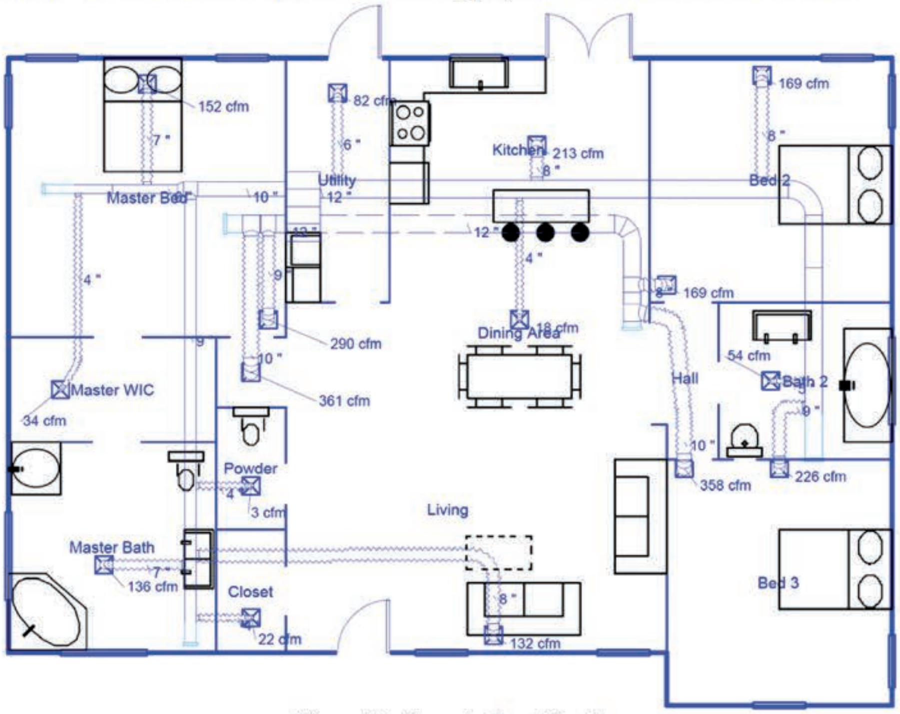


Figure 19: Example Duct Sketch

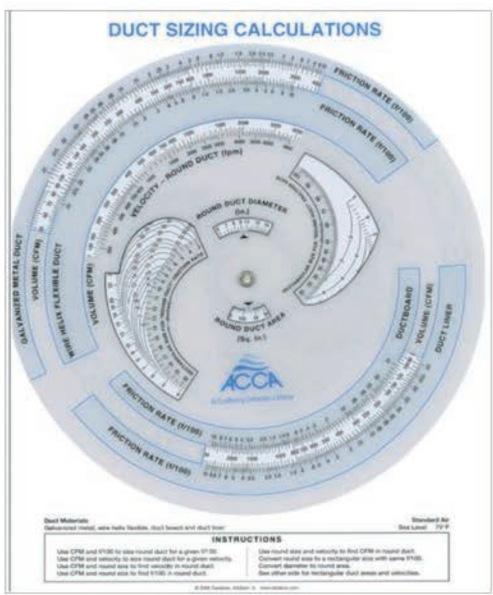


Figure 20: ACCA Duct Calculator

Manual J Abridged Edition Checklist	
The abridged procedure was used, I have initialed next to each block to indicate this dwelling meets each criteria.	
	ONLY a single family detached dwelling.
	HVAC system is a central, single-zone, constant volume system.
	NO radiant heating system.
	NO ventilation heat exchanger (ERV or HRV) or a ventilating dehumidifier.
	ONLY engineered ventilation allowed is provided by piping outdoor air to the return side of the duct sys tem (pressurization effect on infiltration is ignored).
	The indoor design conditions are: Heating 70 °F; Cooling 75 db °F and 45%, 50% or 55% RH.
	ONLY outdoor design conditions equal to the values in Table 1A were used.
	TOTAL window area (including glass doors and skylight area) does not exceed 15 percent of the associated floor area.
	The windows are equitably distributed around all sides of the dwelling - the dwelling has adequate exposure diversity (AED).
	NO Low-e, tinted, reflective, or special glass (All windows, skylights, and glass doors must be clear 1-pane, 2-pane or 3-pane glass)
	ALL skylights are flat. NO skylight light shafts or internal shade.
	ALL windows' internal shade factor is a medium-color blind with slats at 45 degrees.
	ALL U-values and SHGC values for all windows, skylights, and glass doors are from Table 3A and 3C.
	ALL purpose-built daylight windows and skylights have no internal shade.
	ALL windows and glass doors are calculated with applicable bug screen, French door, and projection adjustments.
	NO glass external sun screens.
	ALL windows and glass doors are calculated with applicable overhang adjustments.
	ALL above grade walls are wood frame walls or empty-core block walls (no metal framing, no filled core block).
	ALL exterior finish is brick, stucco, or siding.
	ONLY gypsum board was used for the interior finish.
	ALL below grade walls are empty-core block walls (board insulation; framing and blanket insulation).
	ALL framing is wood (not metal).
	ONLY a dark shingle roof over an attic, a beam ceiling or a roof-joist ceiling.
	ONLY attic or attic knee wall space (when applicable) vented to FHA standards, with no radiant barrier.
	ONLY slab floors with no edge insulation (or 3 feet of vertical insulation that covers the edge). NO insulation below basement floors slab, no sensitivity to width.
	NO insulation under floors over a closed space or on the walls of the closed space.
	Floors over a closed space are insensitive to the tightness of the closed space.
	ONLY infiltration load estimates based on Table 5A (three or four exposures, class 4 wind shielding, no blower door test or component leakage estimate).
	ONLY a sensible appliance load of 1,200 or 2,400 Btuh
	ONLY number of occupants is the number of bedrooms plus one.
	ONLY allowed duct systems (when applicable) are: a. installed in one horizontal plane; b. entirely in a conditioned
	ONLY one of the following duct runs were used: a. An attic installed radial or spider pattern supply system (supplies in room centers) and returns (large return close to air handler or return in closet door); OR b. A trunk and branch supply system in the attic (supplies near inside walls; return riser in floor to ceiling chase); OR c. A trunk and branch supply system in a closed crawlspace or unconditioned basement.
	ONLY the duct leakage rate of R/A=0.12 S./A = 0.24 was used, unless proven by a leakage test.
	ONLY the following duct insulation: R-2, R-4, R-6, or R-8.
	ONLY blower heat adjustment is 500 Watts, if manufacturer's performance data is not discounted for blower heat.
Note: The abridged edition of ***Manual J*** (MJ8ae) shall ONLY be used to estimate heating and cooling loads for dwellings which are totally compatible (100 percent) with this checklist and the descriptions and caveats provided by Appendix 2 and 3. The full version of ***Manual J*** will be used for all other scenarios.	

manual D

manual D

Verifying ACCA Manual D® Procedures

Why are duct design calculations important?

Achieving occupant satisfaction is the principal goal of any HVAC design. For residential air duct designs ACCA's Manual D is the procedure recognized by the American National Standards Institute (ANSI) and specifically required by residential building codes. Air is the first word in air conditioning. If the network of ducts carrying the air is not properly designed then the health and safety of the occupant are at risk, the equipment could fail more quickly, the energy costs could rise, and occupant comfort might be sacrificed.

What problems come from wrong sized ducts?

In order for home owners to be comfortable a duct system must be designed to carry the right amount of air, at the right speed, into the right room. If the ducts are the wrong size then the wrong amount of air will enter the room and may cause:

- The room to be too warm or too cool
- The air to be too drafty and disturb people while they sleep, eat, read, etc...
- The air to be too noisy and drown out conversations, TV or radio programs, etc...
- The air to be too slow – the conditioned air will not circulate or mix well in the room.
- The fan to work harder, possibly fail sooner, and use more energy to move air
- The furnace or air conditioner safety devices to stop equipment operation
- Pressure differentials that may increase energy costs by pushing out conditioned air or drawing in unwanted air

For a more detailed analysis on the design process
visit www.acca.org for *Bob's House*

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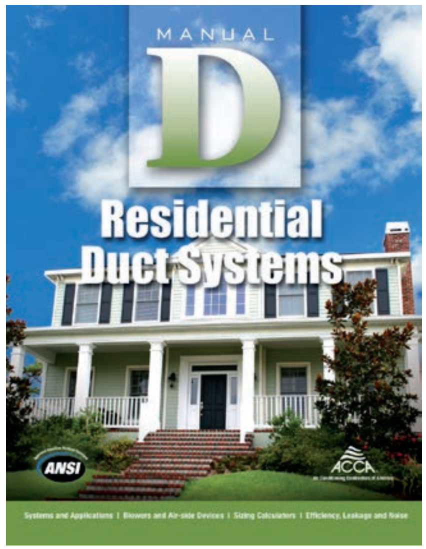
Verifying ACCA Manual D®



Includes Duct Inspection Checklist

ACCA
AIR CONDITIONING CONTRACTORS OF AMERICA®
2800 Shirlington Road, Suite 300
Arlington, VA 22206

Phone 703-824-4477
Fax 703575-4449

ACCA's Manual D Residential Duct Design Checklist

Key Item	Check	Questions to Ask
Information from load calculation	CFM for each room	Does each room have a heating and cooling CFM assigned? (Proportioned air supply based on Manual J8 room-by-room load calculations) (F)
Manufacturer's Data	Manufacturer's External Static Pressure (ESP)	According to the manufacturer's data will the fan produce the specified airflow at the specified static pressure? (Manufacturers produce a graph that relates air flow and static pressure) (A) (B)
	Accessory and device pressure losses	Did the contractor submit the manufacturer's data specifying the pressure drop for any item in the air stream like a high efficiency filter or a hot water coil? (C)
Manual D Friction Worksheet	Available Static Pressure (ASP)	Are supply outlets, return grilles, and balancing dampers listed at a standard 0.03?
		Are the pressure drops listed for other external devices: filters, coils, etc...? (C)
	Total Effective Length (TEL)	Did the contractor calculate the TEL by adding the longest Supply Total Effective Length and the longest Return Total Effective Length? (Total Effective Length = the length of the duct from outlet back to unit + the effective length for all fittings, i.e., elbows, reducers, take-offs, etc…) (D)
	Friction Rate design value	Did the contractor use the Friction Rate Chart or calculate Friction Rate [FR = ASP x 100 / TEL] (E)
Air Distribution System Design	Branch Lead Size	Did the contractor size the ducts based on the design CFM, friction rate, and the duct material used? (G)
	Trunk Size	Did the contractor select a supply trunk duct large enough to accommodate all the supply branch leads?
	Return Trunk Duct Velocities	Did the contractor select the return trunk duct large enough to meet the lower return air velocity requirements? (H)
	Return air path	Verify each occupied room has an open air path (ACCA recommends a ducted return for each bedroom, den, library, etc…)
Manual T	Register and Grille Face Velocities	Does the air velocity across the register or grille exceed the Recommended Velocity Chart? (Grille manufacturers list the face velocity for grilles and registers at a given CFM, e.g., 12 x 4 - Model XYZ, 500fpm at 120cfm (I)

Friction Rate Worksheet

Step 1) Manufacturer's Blower Data

External Static Pressure (ESP) = 0.70 IWC CFM= 1200 CFM

Step 2) Device Pressure Losses (DPL)

Direct expansion refrigerant coil	0.23 IWC
Electric heat resistance coil	______
Hot water coil	______
Filter	0.18 IWC
Humidifier	______
Supply outlet	0.03 IWC
Return grille	0.03 IWC
Balancing dampers	0.03 IWC
Other device	______
Total device losses	0.50 IWC

Step 3) Available Static Pressure (ASP)

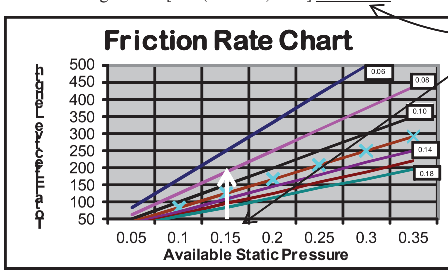
ASP = ESP – DPL (Step 1 – Step 2) 0.20 IWC

Step 4) Total Effective Length (TEL)

Supply side TEL + Return side TEL = 200 ft TEL

Step 5) **Friction Rate** Design Value [FR= (ASPx100)÷TEL] 0.10 IWC from chart below

Friction Rate Chart



A From manufacturer's data—equipment CFM at rated capacity

B From Manufacture's Blower Performance Data corresponding to the CFM (#1)

C From Manufacturer's Performance Data

D **Total Effective Length** ≈ loss from duct lengths, reducers, elbows and other fittings

E **Friction Rate** is found by reading bottom scale to 0.20 and up the side scale to 200 feet the intersecting line is the 0.10. That is the design friction rate. This example, 0.10, is within the acceptable friction rate range.

F The **Design CFM** for each room is based on the larger of the Cooling or Heating CFM. Those heat and cool CFM come from the allocation of the system's capacity based on each room's heating and cooling needs.

G The **Friction Rate** is used to determine the duct size.

H The **return duct size** is based on the friction rate and then may be adjusted to a larger size to meet recommended velocity.

I **Grille and register sizes** should be selected to ensure the velocities are acceptable.

Recommended Velocity (FPM) (Manual D, Table 3-1)

	Supply				Return			
	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	

Table of Useful Air Distribution System Design Information

Zone:	One	Design Friction Rate	0.10	Type of System:	Trunk and Branch
Construction Material	Supply Air Trunk	Metal		Supply Air Branch	Flex
Construction Material	Return Air Trunk	Duct board		Return Air Branch	Flex
R-Value of Insulation	Supply	R6		Return	R6

Room	Design CFM	Supply Duct Size(s)	Supply Grille(s) Size, and Velocity	Return Duct Size(s)	Return Grille Size and Velocity
Bedroom 1	150	1 – 8"	1 - 14x6, 600fpm	(9")- 12"	14x14, 300fpm
Walk-in-Closet	15	1 – 4"	1 - 8x4, 450fpm		
Bedroom 2	100	2 – 6"	2 - 10x4, 600fpm	(7") - 8"	14x8, 275fpm
Bedroom 3	100	1 – 7"	1 - 12x4, 600fpm	(7") - 8"	14x8, 275fpm
Living Room	275	2 – 8"	2 - 14x6, 575fpm	(16")- 18"	24x24, 350fpm
Den	125	1 – 8"	1 - 14x6, 600fpm		
Dining	125	2 – 6"	2 - 10x4, 600fpm		
Foyer	80	1 – 6"	1 - 10x4, 600fpm		
[illegible]	125	2 – 6"	2 - 10x4, 625fpm		
Bath 1	65	1 – 6"	1 - 10x4, 600fpm		
Bath 2	40	1 – 5"	1 - 8x4, 500fpm		
Bath 3					
TOTALS	1200				

ACCA does not recommend installing return ducts in kitchens, baths, laundry, or utility rooms

Notes:

Types of Supply System: Trunk and Branch, Perimeter Loop, Radial

Construction Materials: Sheet metal, Fiberglass Ductboard, Rigid Round Fiberglass, Flexible Vinyl Duct, Fiberglass Duct Liner w/ Facing, Flexible Metal Duct

manual S

manual S

Sponsored by the ACCA
Codes Committee

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ACCA (Air Conditioning Contractors of America) is dedicated to excellence in the HVACR industry. As the largest HVACR contractor organization, ACCA is committed to helping its members succeed. Some of the fundamental ways in which our efforts are seen, are in the technical resources and industry standards, that guarantee quality HVACR design, installation and maintenance.

The ACCA Codes Committee was formed to address code issues and in particular, *to advise and assist ACCA in beneficially representing the contractors in the code processes that affect the HVAC industry*. This document has been written for code officials, seeking to verify that HVAC equipment has been selected in order to meet the home's load requirements.

For a more detailed analysis on the design process
visit www.acca.org for
Bob's House

To order ACCA Manual S
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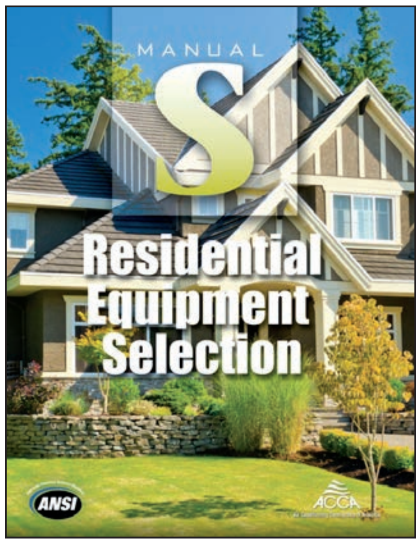
Verifying ACCA Manual S® Procedures

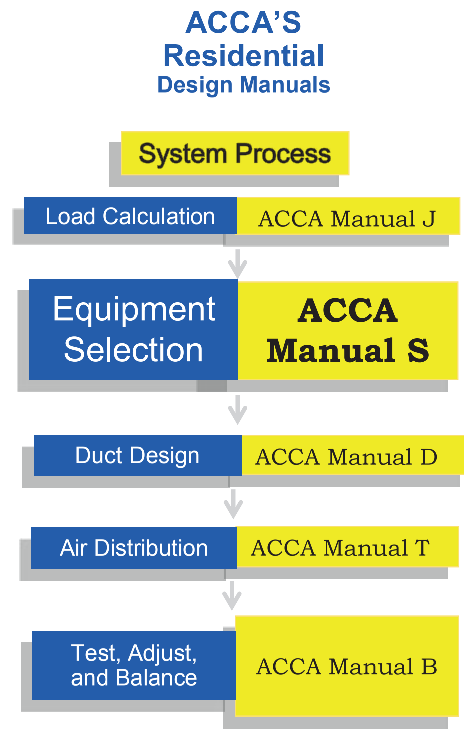


Includes Equipment Selection Checklist & Example

Verifying ACCA Manual S® Procedures

Why is proper equipment selection important?
Achieving occupant satisfaction is the principal goal of any HVAC design. Occupant satisfaction is maximized when the heating and cooling equipment are the correct type and size to meet the capacity requirements from the Manual J load calculation.

For residential equipment selections, ACCA's Manual S®, is the only procedure recognized by the American National Standards Institute (ANSI). If the Manual J load calculation is done then the next step is to select the equipment that will deliver the necessary heating and cooling.



What problems come from the wrong size equipment?
Undersized equipment will not meet the customer's comfort requirements at the design specifications.

Oversized equipment will create other problems:

- Degraded humidity control in the summer.
- Occupants may suffer the effects of an increased potential for mold growth. These same conditions also may contribute to asthma and other respiratory conditions.
- The temperature may feel right at the thermostat but the temperature in other rooms will suffer from the oversized equipment going through short operation cycles. Short cycles can cause temperature swings as the equipment over-conditions, stops, then over-conditions, etc…
- Hot and cold spots between rooms because the thermostat is satisfied but the room is not.
- Oversized equipment generally requires larger ducts, increased electrical circuit sizing and larger refrigeration tubing. These cause higher installed costs and increased operating expenses.
- The equipment starts and stops more frequently, this causes excessive wear and can increase maintenance costs / service calls.

In these unfavorable conditions occupants will experience discomfort and dissatisfaction.

What are some reasons for oversized equipment?
Manufacturers take great care in measuring and testing how well their equipment performs at different operating conditions.
When contractors use this data to select the equipment they will meet the heating and cooling needs of their customers.
Two main reasons for oversized equipment are either that: (1) a guess was made on the equipment's capacity at the design conditions or (2) mistakes were made in the selection process.

Equipment Selection Checklist

#	Key Item	Verify	Verification Questions
1	Design Conditions	The design conditions fall within specifications.	Do the design conditions fall within the minimum standards for this region as found in Manual J8 Table 1A or 1B? (A)
		The information from the Manual J load calculation was transferred accurately.	Was the Total Heat Gain / Loss information used to evaluate equipment candidates? (B)
2	OEM's Performance Data	The equipment manufacturer's performance parameters match the design parameters used to calculate the heat load.	Does the manufacturer's performance parameters match the design parameters used to calculate the home's heat load (i.e., outdoor dry-bulb, indoor dry-bulb, and indoor wet-bulb)?
			If the performance data parameters are more than 5% greater or less than the design parameters then did the contractor interpolate the equipment manufacturer's performance parameters to match the design parameters used to calculate the heat load?
3	Equipment Performance	Estimated Cooling – CFM based on Temperature Difference	Was the Sensible Heat Ratio calculated? (Sensible Load / Total Load)? (C)
			Was the SHR used to find the proper air flow? (D)
		Equipment selected satisfies Total Btus (for cooling the Sensible and **Latent** load)	Is the total heating capacity of the selected equipment ≤140% of the designed total heating load? (If not reduce equipment size) (E)
			Is the total cooling capacity of the selected equipment ≤115% of the designed total cooling load ? (If not reduce equipment size) (F)
			Does the "Sensible" and/or "Latent" capacities of the selected equipment meet the load's requirements? (G)
			If a heat pump in a very cold climate (heating is primary concern) does the total cooling capacity of the selected equipment exceed 125% of the designed total cooling load?
4	Auxiliary Heat	Heat Pump Balance Point	Does the electric auxiliary heat provide the necessary BTUs to makeup difference in capacity from the heat pump's balance point to the design load conditions? (H)

Equipment Selection using an ExampleChecklist

Design			Application Data: Equipment Capacity		
Winter Design Conditions			A furnace was selected for comparing "heating only" design and performance. Other types of equipment may be used.		
Outdoor °F:	27°F (A)	From Manual J8 Table 1A or 1B			
Indoor °F:	70°F	Manual J8 §3-6 defaults to 70°F	Furnace Model Number:	FU600300	Fictitious furnace
Total Calculated Heat Loss	50,981Btu/h (B)	Determined by Manual J8 load calculation	Output BTUH:	52,000Btu/h (E)	Furnace Btu/h Output: (≤ 140% of calculated loss)
Summer Design Conditions			A heat pump was selected for comparing cooling and heating design and performance. Other types of equipment may be used.		
Outdoor°F:	85°F (A)	From Manual J8 Table 1A or 1B			
Indoor °F:	75°F	Manual J8 §3-6 defaults to 75°F			
Entering Wet Bulb (EWB):	63°F	Manual J8 §3-6 defaults to 63°F EWB (≈ 75°F / 50% RH)	Outdoor Unit Model Number:	HP-030	Fictitious heat pump
Total Heat Gain	27,543Btu/h (B)	Determined by Manual J8 load calculation	Total Cooling Capacity (≤ 115%)	28,400Btu/h (F)	These capacities are from manufacturer's performance data at the **DESIGN CONDITIONS:** 85°F ODT, 1,000CFM, and 63°F EWB
Sensible Heat Gain	23,321Btu/h (G)		Sensible Cooling Capacity (≈ Sensible Gain)	21,600Btu/h (G)	
Latent Heat Gain	4,222Btu/h (G)		Latent Cooling Capacity (≈ Latent Gain)	6,800Btu/h (G)	
Sensible Heat Ratio (SHR)	85% (C)	See formula below	Indoor Unit Model Number:	AH-030	Fictitious air handler
Design Air Flow	1,116 CFM (D)	The "*TARGET*" airflow, we look for equipment that operates in this range (+/- 10%), on **medium** fan speed	Indoor Blower CFM (CFM in manufacturer's performance data at rated capacity-medium fan speed):	1,000 (D)	The actual equipment rated airflow, (medium fan speed optimal) should fall within target CFM,(+/- 15%)
(C) $SHR = \frac{\text{Sensible Heat}}{\text{Total Heat Gain}}$ .85	$\frac{23{,}321\text{Btu/h}}{27{,}543\text{Btu/h}}$ (D) 85% ≈ 19° Design Temp		Btuh Difference between Heat Pump Balance Point and Total Heat Loss	30,281 Btu/h (H)	This heat pump can only produce 20,700Btu/h at design conditions. More capacity is required. (Air Conditioners do not have a balance point.)
Sensible Heat Ratio versus Temperature Design Value	$CFM = \frac{\text{Sensible Heat Gain}}{\text{Design Temp x 1.1}}$		Auxiliary Heat (Circle): Electric Gas Oil	10 KW (H)	In this example the auxiliary heat is electric, the formula for electric heat is KW= Btu/h ÷ 3.413
	$1{,}116\ CFM = \frac{23{,}321\text{ Btu/h}}{19 \times 1.1}$				

SHR	Recommended Temp. Design
Below 0.80	21°F
0.80 – 0.85	19°F
Above 0.85	17°F

From Manual J8 Tables | From Manual J8 Load Calculation | From Equip. Performance Data

hvac installation tips

Success with the 2015 Virginia Construction Code
in New Construction Homes

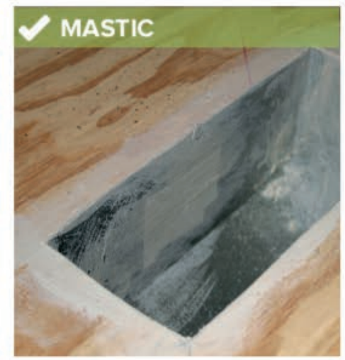
HVAC INSTALLATION

viridiant
advanced energy
SEEA SOUTHEAST ENERGY EFFICIENCY ALLIANCE
VIRGINIA DHCD

IECC Tech Tips
VIRGINIA

TECH TIPS:
HVAC Installation

1. Seal all duct terminations to drywall and/or subfloor and all HVAC penetrations in the building envelope with foam, caulk or mastic. Use fire-rated sealants where applicable.



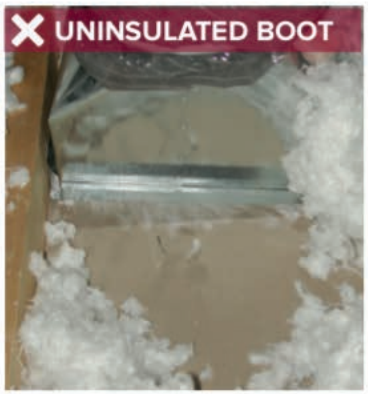
2. Seal all HVAC components at all joints, seams and corners.

3. Mechanically fasten all metal duct work with screws. Attach the inner liner of flexible ducts with nylon/plastic straps and tighten with a manufacturer-approved tool.

IECC Tech Tips
VIRGINIA

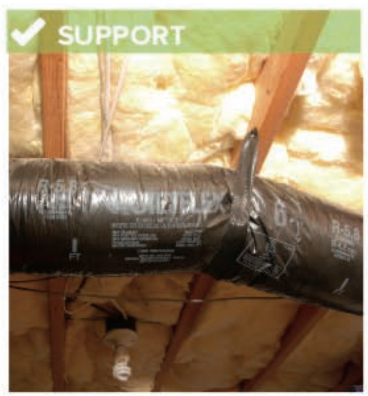
TECH TIPS:
HVAC Installation

4. Insulate all ducts outside of conditioned space to at least R-6 and supply ducts in attics to at least R-8



5. Do not compress insulated flexible ducts more than the thickness of the insulation.

6. Support flexible duct (including spot ventilation) at least every 4 feet and do not bend greater than 90°.



IECC Tech Tips
VIRGINIA

TECH TIPS:
HVAC Installation

7. Install outside air ventilation intakes at least 10 feet from any exhaust vent or stack.

✗ WRONG LOCATION

✓ RIGHT LOCATION

8. Coordinate bath fan exhaust duct direction with electrical contractor.

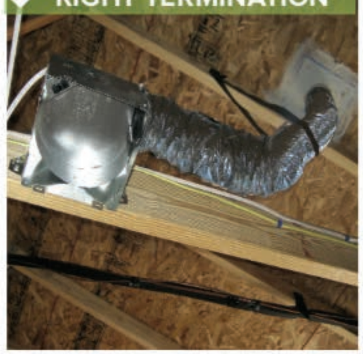
✗ WRONG DIRECTION

✓ RIGHT DIRECTION

9. Terminate exhaust ventilation duct work to the outside and install a screen over the termination.

✗ WRONG TERMINATION

✓ RIGHT TERMINATION



10. For heat pumps, install a heat strip outdoor temperature lockout that prevents supplemental heat operation and set it to the balance point.

✗ DISCONNECTED

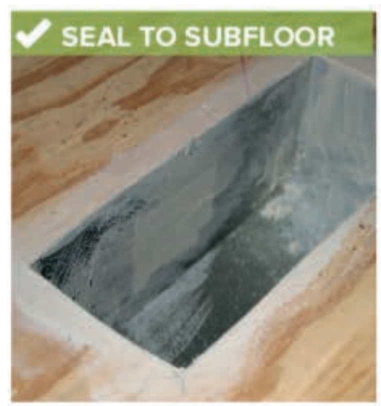
✓ RIGHT INSTALLATION

IECC Tech Tips
VIRGINIA

TECH TIPS:
HVAC Installation

Viridiant has seen success with sealing all joints in the air distribution system with bucket duct mastic and fabric mesh.

The 2015 Virginia USBC requires measuring the total duct leakage, unless the ducts and air handler are completely within conditioned space.



IECC Tech Tips
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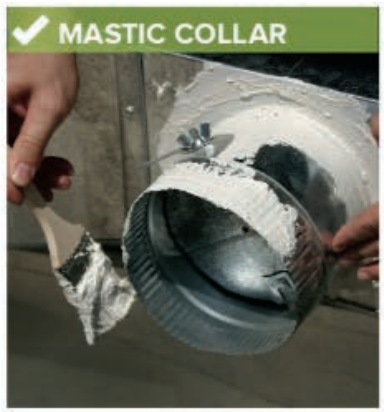
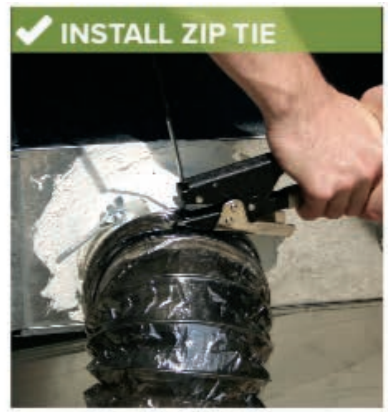
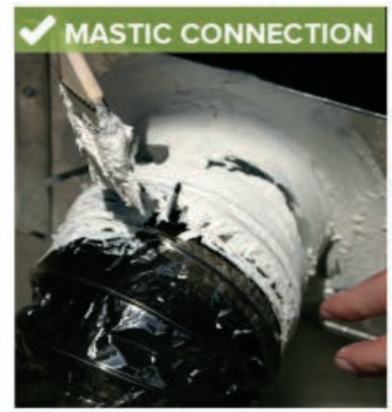
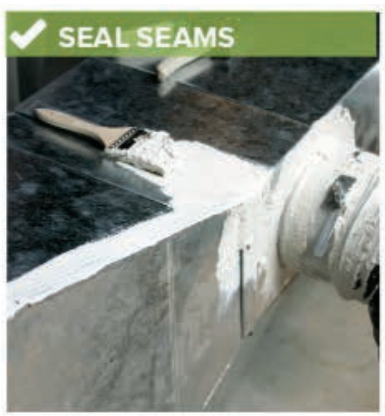








hvac system design

Understanding Select Fields on the Residential Plans Examiner Review Form for HVAC System Design

HVAC LOAD CALCULATION (IRC M1401.3)

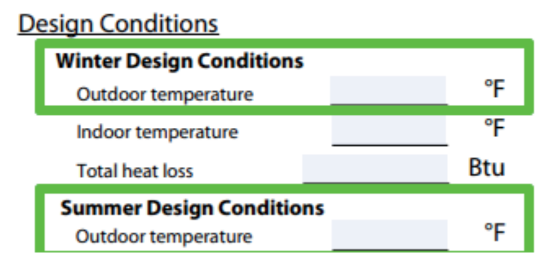
Design Conditions

For the location closest to the site of the home:

- The **Winter Design Conditions** outdoor temperature should be the temperature from the **Heating (99% Dry Bulb)** column.
- The **Summer Design Conditions** outdoor temperature should be the temperature from the **Cooling (1% Dry Bulb)** column.

ACCA Manual J Outdoor Design Temperatures for Virginia

Map Letter	Location	Heating (99% Dry Bulb)	Cooling (1% Dry Bulb)
A	Charlottesville	18	91
B	Danville AP	16	92
C	Fort Belvoir	18	93
D	Fredericksburg	14	93
E	Hampton Langley AFB	24	91
F	Harrisonburg	16	91
G	Lynchburg AP	17	90
H	Newport News	22	92
I	Norfolk AP	24	91
J	Oceana NAS	25	91
K	Petersburg	17	92
L	Quantico MCAS	21	92
M	Richmond AP	18	92
N	Roanoke AP	17	89
O	Staunton	16	91
P	Sterling	14	90
Q	Washington, National AP	20	92
R	Winchester	10	90


Design Conditions

Winter Design Conditions

Outdoor temperature ______ °F

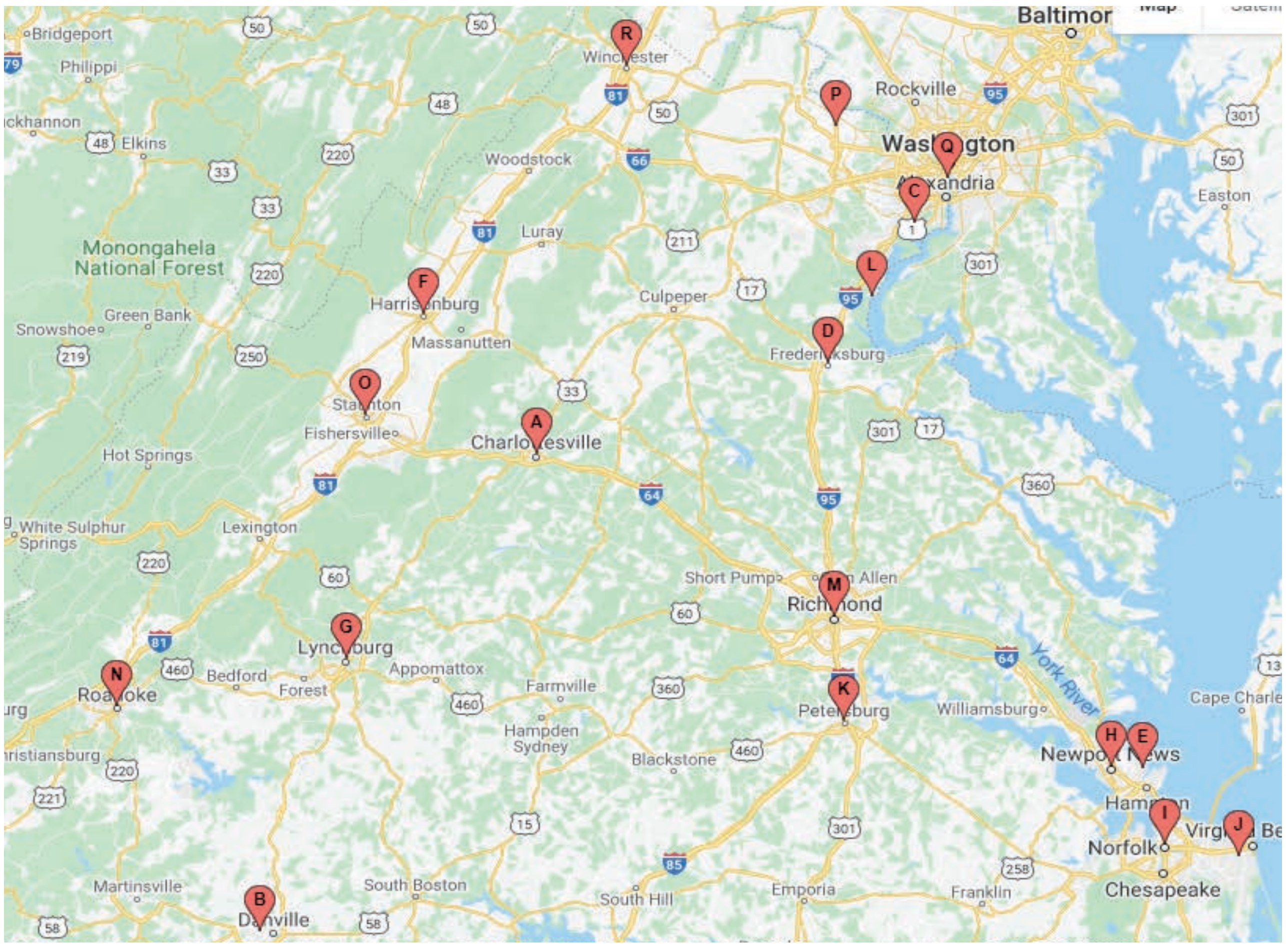
Indoor temperature ______ °F

Total heat loss ______ Btu

Summer Design Conditions

Outdoor temperature ______ °F

Map of Virginia Design Temperature Locations



HVAC LOAD CALCULATION (IRC M1401.3)

Design Conditions

Winter Design Conditions

Outdoor temperature		°F
Indoor temperature		°F
Total heat loss		Btu

Summer Design Conditions

Outdoor temperature		°F
Indoor temperature		°F

The **Winter Design Conditions** indoor temperature should be 70° or per Local Code.

The **Summer Design Conditions** indoor temperature should be 75° or per Local Code.

Design Conditions

Winter Design Conditions

Outdoor temperature		°F
Indoor temperature		°F
Total heat loss		Btu

Summer Design Conditions

Outdoor temperature		°F
Indoor temperature		°F
Grains difference	Δ Gr @	% Rh
Sensible heat gain		Btu
Latent heat gain		Btu
Total heat gain		Btu

In the Manual J reports, there will be a section that defines the building loads.

There will be different language used in different software platforms. The manual J reports may not directly list **Total Heat Loss** and may instead show **Total Heating Required**. The value in the HVAC System Design form should match the manual J report values.

Building Loads		
Total Heating Required Including Ventilation Air:	12,616	Btuh
Total Sensible Gain:	7,962	Btuh
Total Latent Gain:	1,859	Btuh
Total Cooling Required Including Ventilation Air:	9,821	Btuh

Cooling is described by the Sensible Gain (heat gain), Latent Gain (moisture load), and **Total Heat Gain** or **Total Cooling Required**, which is the sum of the Sensible and Latent loads.

HVAC LOAD CALCULATION (IRC M1401.3)

Building Construction Information

The **number of occupants** should be the number of bedrooms + one (this assumes two people in the main bedroom).

On **the manual J Summary Report**, there will be a line for **People**. This should match the number of occupants shown on the Residential Plans Examiner Form.

Building Construction Information

Building

Orientation (Front door faces)

North, East, West, South, Northeast, Northwest, Southeast, Southwest

Number of bedrooms

Conditioned floor area Sq Ft

Number of occupants

People:	4	10,027

Building Construction Information

Building

Orientation (Front door faces)

North, East, West, South, Northeast, Northwest, Southeast, Southwest

Number of bedrooms

Conditioned floor area Sq Ft

Number of occupants

Check Figures	
Square ft. of Room Area:	977

The **Conditioned floor area** is found in the manual J in several places as **Square Foot of Room Area**. In the manual J, this may be either the entire building square footage or the square footage served by a system or contained in a zone, depending on which report is being viewed.

Quick Check

The **square feet per ton** is a quick metric to assess. Historically, this value was 400-600 square feet per ton. In new construction homes this will typically fall between 800-1300 square feet per ton. Values outside of that may not be incorrect but may be worth closer scrutiny.

Check Figures			
Total Building Supply CFM:	330	CFM Per Square ft.:	0.338
Square ft. of Room Area:	977	Square ft. Per Ton:	1,104
Volume (ft³):	7,816		

This value is part of the manual J reports. If it hasn't been included, it can be checked with data in the Residential Plans Examiner Review form.

1. Take the Total Heat Gain value from the Summer Design Conditions section
2. Divide that number by 12,000 to get tons
3. Divide the conditioned floor area by the result from step 2.

Example:

Total heat gain: 15,189

Conditioned square footage: 1,340

1. *15,189 Btu*
2. *15,189 / 12,000 = 1.27 tons*
3. *1,340 / 1.27 = 1,055 sq ft per ton*

Summer Design Conditions		
Outdoor temperature		°F
Indoor temperature		°F
Grains difference	Δ Gr @	% Rh
Sensible heat gain		Btu
Latent heat gain		Btu
Total heat gain		Btu

VIRTUAL INSPECTIONS

VIRTUAL INSPECTIONS

recommended practices

Recommended Practices for Remote Virtual Inspections (RVI)

Recommended Practices for Remote Virtual Inspections (RVI)

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Table of Contents

Preface

Technological advances have created enormous possibilities in all aspects of life, including the building construction and safety industry. Digital and online tools for building design, construction and administrative functions, such as permit application, plan review, inspection and commissioning, have drastically increased the efficiency and accuracy of achieving safe and resilient communities. Local, state and national governments have taken advantage of advancing technologies and have incorporated various levels of digitization into their processes in order to save time and reduce costs. Examples of such efforts include online offering of permit applications, payment of permit fees, submittal of plans and digital plan review.

The speed of adoption and implementation of technology, however, varies by geographic region and depends on a number of factors, including the availability of financial resources and the infrastructure needed to support the technology. Many Authorities Having Jurisdiction (AHJs) have implemented technology at various levels with good success and have embraced greater reliance on digitization as time goes by.

The 2020 global coronavirus pandemic created an impetus in speeding the implementation of modern technologies and taking advantage of new ideas in a much shorter time frame. The spread of COVID-19 and the closing of most businesses and social activities in many parts of the world to create social distancing resulted in many sectors of the economy searching to find new solutions for conducting business.

Many AHJs needed to come up with solutions to perform all aspects of codes and standards administration from remote locations and/or home offices. One such solution using available technology is Remote Virtual Inspections (RVI).

RVI is a method of inspection that allows the needed inspections to proceed in a timely manner by the owner or contractor located on the jobsite and the inspector or inspection teams performing the inspection remotely. While this practice gained good acceptance and implementation during the weeks and months of COVID-19 social distancing, its advantages are so great that it will likely become a popular and routine tool for the foreseeable future.

The advantages and opportunities created by RVI locally, nationally and globally are enormous, allowing those with technical expertise in their specific subjects to offer their services across the globe. Building code specialists, inspectors and consultants will be able to provide services and consulting from far distances and to help building safety and resiliency anywhere needed at the local, national or global level.

Recommended Practices for Remote Virtual Inspections (RVI) was developed based on study, research, and discussions related to items that should be considered and addressed for an effective and consistent RVI program and to assist AHJs in implementing the readily available technologies in the adoption and implementation of their own RVI program.

ICC welcomes your comments and feedback to improve future editions of this Recommended Practices publication. Submit feedback at www.iccsafe.org/RVI.

About the International Code Council®

The International Code Council is a nonprofit association that provides a wide range of building safety solutions including product evaluation, accreditation, certification, codification and training. It develops model codes and standards used worldwide to construct safe, sustainable, affordable and resilient structures. The mission of the Code Council is to provide the highest quality codes, standards, products and services for all concerned with the safety and performance of the built environment. ICC Evaluation Service (ICC-ES) is the industry leader in performing technical evaluations for code compliance fostering safe and sustainable design and construction.

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Family of Solutions:

1.0 Introduction

Hand-held devices such as smartphones and tablets have capabilities for real time, online communication of videos and photos. Use of advanced tools and technologies, combined with the power of such hand-held devices, has made it possible for anyone to observe the construction activities of a jobsite from any location, near or thousands of miles away. Using Remote Virtual Inspection (RVI) allows construction projects to continue without impediment and allows the Authority Having Jurisdiction (AHJ) to continue to provide the vital services needed for construction of safe buildings.

Purpose and Scope

The purpose and scope of these Recommended Practices is to provide guidance to the Authority Having Jurisdiction (AHJ) when implementing a Remote Virtual Inspection (RVI) program as well as to the construction industry user. This document specifically addresses implementation and administration of RVI. These procedures are organized in a fashion that can be readily implemented by the AHJ as part of their inspection procedures. This document also provides recommended practices to construction industry professionals submitting to an RVI.

Until recently, Remote Virtual Inspections have been conducted only by a few AHJs at varying levels. As a result, there has not been a standardized program that addresses how to prepare for, conduct and participate in these types of inspections.

2.0 Definitions and Acronyms

1. **RVI: Remote Virtual Inspection:** Remote Virtual Inspection, also known as RVI, is a form of visual inspection which uses visual or electronic aids to allow an inspector or team of inspectors to observe products and/or materials from a distance because the objects are inaccessible or are in dangerous environments, or whereby circumstances or conditions prevent an in-person inspection.
2. **AHJ: Authority Having Jurisdiction.**

3.0 Remote Virtual Inspection Process

Remote Virtual Inspections (RVI) may provide benefits to AHJs and customers alike. In certain circumstances, an RVI may provide a better quality inspection with an increase in efficiency and cost savings. It will increase the efficiency of the inspection process utilizing modern technology. Depending on the location and complexity of a project, some limitations may impact its use. In cases where an RVI is not suitable or technology fails to provide sufficient visual clarity (i.e., poor/no service or Wi-Fi, poor lighting, etc.), an onsite inspection may be required. Subject to local approval, the AHJ may choose to use an approved third-party inspection agency or utilize staff inspectors. Where Wi-Fi and/or cellular reception are poor or not available, some AHJs may consider allowing the contractor to provide an acceptable electronic documentation of the area that needs an inspection for review by the assigned inspector or team of inspectors.

A clear understanding of the RVI requirements and communication throughout the process by both parties is paramount to the completion of a successful inspection. The inspector will check all aspects of the permitted construction project to the adopted codes and other applicable laws and regulations no differently than if it were an onsite inspection. Identification of the project jobsite location, posted address and its location within the building will be a critical part of the process.

The applicable Codes and Standards to be used for RVI are the same as the adopted codes and referenced standards of the AHJ. The implementation of the RVI is intended to achieve the same results as the typical in-person site inspection by applying the provisions of adopted codes such as the IBC®, IRC®, IPC®, IFC® and other applicable and adopted International Codes.

AHJ: Scheduling Remote Virtual Inspection

1. Schedule Inspection Time.
    - 1.1. All remote inspections should be scheduled a minimum of one business day prior to the requested date.
    - 1.2. Schedule inspection either online or by telephone.
    - 1.3. Schedule sufficient time for the type of inspection requested.
    - 1.4. AHJ to send an inspection confirmation email or text to the customer with the date, approximate time of RVI and name of inspector.
2. Time slots for inspections.
    - 2.1. Anticipated length of inspections per type (i.e., water heater installation, HVAC replacement, etc.) needs to be established.
    - 2.2. Each customer will be given an approximate time window for inspection.
3. Post the earliest available time for remote inspections and the latest time of the day a remote inspection may be scheduled Monday through Friday or other days selected by the AHJ.
4. Schedule after-hours or emergency inspections on a case-by-case basis.
5. Determine the types of inspections allowed for remote inspections. See Appendix A for examples of qualified inspection activities.
    - 5.1. All inspections may qualify for an RVI, depending on the AHJ's resources and policies.
6. Determine which type of videotelephony is available for use and is compatible with the AHJ's permitting software and videotelephony equipment.
    - 6.1. Videotelephony platform examples: FaceTime, Google Duo, Zoom, WhatsApp, Skype, Tango, WebEx, Microsoft Teams, GoToMeeting, etc.

Customer: Scheduling Remote Virtual Inspection

1. Ensure there is an active permit issued or certificate application filed or obtain the appropriate one prior to attempting to schedule an inspection for the project in question.
2. Electronically sign a notice indicating that the permit holder of record or representative:
   2.1. Consents to the use of the remote inspections.
   2.2. Is responsible for their own safety during the remote inspection.
   2.3. Allows the complete use of the videos and photos of the remote inspection by the AHJ.
   2.4. Certifies they are making available the site and inspection items truthfully and to the best of their ability.
   2.5. Is responsible for compliance with all codes and standards applicable to the project.
   2.6. Acknowledges that participation in the remote inspection program is voluntary (if not a mandatory program within the AHJ's jurisdiction).
   2.7. Acknowledges that the decision to perform an RVI is at the sole discretion of the AHJ.
3. Prior to scheduling the inspection, confirm that the minimum criteria for a remote inspection are met. See Appendix A for examples of qualified inspection activities.
   3.1. Note that some types of inspections may be too complex or otherwise not compatible for remote inspections.
4. Call to schedule an appointment with the AHJ.
5. Must be at least 18 years old or with an adult to perform the video inspection.
6. When scheduling the inspection, provide the address, permit number, and type and number of requested inspections.

Customer: Prepare for Remote Virtual Inspection

1. Prior to the inspection, ensure that:
   1.1. The jobsite is safe at all times for the individual(s) using the device during the remote inspection including health safety.
   1.2. The device (smartphone, tablet, drone, etc.) is fully charged and has a suitably charged additional power supply (battery pack).
   1.3. The use of a noise-canceling headset is recommended.
   1.4. The jobsite has high-speed Wi-Fi connectivity or minimum 4G cellular service with a strong signal.

1.5. The necessary tools based on type of inspection are readily available.

1.5.1. For example, carry a flashlight, tape measure, level, step ladder (for close ups of ceiling), GFCI tester, etc. An extending pole for the video device, such as selfie pole, may be very helpful in taking the smartphone or other video device closer to the point of inspection in various places such as very high ceilings.

2. Have approved plans, permit card, and other necessary construction documents available onsite.
3. Make sure good lighting is available and clear the area of any unnecessary objects.
4. All features applicable to the required inspection must be visible at the time of the remote inspection. These features must be captured sufficiently and clearly for the inspector to evaluate.
5. If at any point the inspector believes that the remote inspection process is not allowing them to properly assess compliance, they may require that a site inspection be conducted at a future date or instruct the customer to make different arrangements.

5.1. In areas within the jobsite where there is no Wi-Fi or cell service, at the sole discretion of the inspector, the contractor may be allowed to provide video and/or photographic documentation of the item(s) to be inspected for review by the authorized inspector at a later time.

6. The onsite inspection may be conducted by an approved third-party inspection agency or by the AHJ's inspection staff.

Prepare to Receive Remote Virtual Inspection Call

1. Ensure that the lens and screen of any device being used to capture images or video has been cleaned. Dust, grit, smudges, etc., might interfere with the image quality and distorting the inspector's view.
2. To minimize interruptions during the RVI and to ensure that the video feed will be uninterrupted, make sure that all notifications are turned off in the Settings of the mobile device used for the RVI. Should the video be interrupted, the inspection could be delayed or have to be rescheduled.
3. Be prepared to answer the inspector's call at any time during the scheduled timeframe. Be cooperative and closely follow the inspector's instructions.
4. As each site and inspection is different, allot the proper amount of time for the type of inspection and accessibility of the site.
5. Carefully follow the inspector's instructions for where to direct the device and for covering the site. Do not rush the inspector but allow him or her adequate time to conduct the RVI to his or her satisfaction.
6. As much as possible, minimize background noise as that can interfere with communication with the inspector.

What to Expect During the Inspection

1. Begin inspection at the street view looking at the structure with the address or other required jobsite identification in the video display.
   1.1. Inspector may also verify location through GPS/Geotagging where the service is available.
2. Follow the directions of the inspector with respect to the order and direction of inspection.
3. As the inspection progresses, write down any items that the inspector finds that need to be corrected. Be sure the notes are detailed and ask questions of or seek clarification from the inspector at the time of the RVI.
4. If provided a permit card, do not write on it. During the next in-person visit, the inspector should update it then.
5. In most cases, the inspector will relay the results of the inspection before the end of the RVI of passing, failing or not ready for inspection.
6. Do not cover any work needing corrections until corrections are verified by reinspection. Reinspection fees may apply in accordance with the AHJ's policies.
7. Note: At a minimum, there must be an adult of the required legal age on site who will represent the owner/representative during the entire duration of the RVI.
8. The owner/representative must be able to verbally communicate with the remote inspector at all times during the inspection.

Inspection Results

1. Results of the inspection will be entered into the AHJ's permit database as soon as practicable after the RVI is completed. It is important to note that the inspection was completed using the RVI process.
2. Where an approval tag for utility connections is required, the AHJ should work directly with the utility company.
3. Following the inspection:
   3.1. Inspection comments will be available on the AHJ's website, within the AHJ's normal timelines, indicating passing or failing with the list of corrections when applicable.
   3.2. In addition, the inspector may email the inspection information upon request to the customer as soon as inspection information is available.
   3.3. The inspector will determine whether additional fee(s) for reinspection is required.
4. Scheduling a reinspection or the next inspection needed is based on availability of time slots.
5. The authorized inspector may provide an option for the owner/representative to submit electronic documentation that a deficiency or deficiencies have been corrected.
6. It is incumbent on the owner/representative to provide the address and permit number on all submitted correspondence or communications.

Maintaining Records of Inspections

Required inspection records, including, but not limited to, correction notices, electronic media, recordings or photo documentation, shall be maintained in accordance with the AHJ's policy, laws, regulations, and applicable codes, and may be subject to disclosure.

4.0 Training and Communication

Training and effective communication of processes, procedures and requirements are essential and a critical part to the success of any program. This program is no different as it lends itself to new technology, new programs, and methods that are in many cases, new to the building construction and safety industry. Therefore, training of the AHJ's staff as well as the building industry on the various programs and procedures will save time and money and make the administrative and enforcement process a positive experience with minimal confusion. Training also leads to better communications between an AHJ and its customers.

Staff Training

1. Ensure all staff are trained in the appropriate areas of responsibility.
2. Permit Technicians:
    - 2.1. Review of approved permit applications relative to RVI requirements.
    - 2.2. Required departmental approvals are complete.
    - 2.3. Fee collection process.
    - 2.4. Required documents for the project (plans, calculations, etc.).
3. Remote Inspection Staff:
    - 3.1. Inspection software and hardware.
    - 3.2. Remote inspection procedures.
    - 3.3. Types of platforms used (Facetime, Skype, etc.).
    - 3.4. Reinspection fee procedures.
    - 3.5. Recording inspection results in permit tracking system.

Customer/Applicant

1. Ensure the owner and representative are trained in their areas of responsibility.
2. Permit applicant:
   2.1. Knowledge of the AHJ's departmental approvals required for the project.
   2.2. Knowledge of the AHJ's RVI protocol.
   2.3. Ensuring project meets RVI protocol.
   2.4. Ensure that the project is ready for the RVI at the scheduled time.
   2.5. Comply with the inspector's direction.
3. Owner/Contractor/Subcontractor:
   3.1. Requesting remote inspection process.
   3.2. Knowledge of remote inspections procedures.
   3.3. Platform required (Facetime, Skype, Google Duo, etc.).
   3.4. Jobsite communication requirements (Wi-Fi, 4G, etc.).
   3.5. Communication skills.

Additional Considerations

1. Adopt basic online security practices. Consult with your IT department for guidance.
2. Consult with your legal counsel to ensure compliance with all federal, state and local requirements related to your RVI program. For example, you may want to consult counsel to find out whether a homeowner's release is needed to conduct an RVI.
3. Ensure that all staff have access to the codes and standards that are applicable to what they are inspecting. The Code Council's Digital Codes Library (https://codes.iccsafe.org/) offers online access to all ICC model codes and standards and most state codes.
4. Document lessons learned to improve your RVI program and to support potential long-term establishment of virtual inspection processes.

5.0 Appendix A (Examples of Potential Activities)

The following are a few examples of construction activities that may be considered to be included in a RVI Program. This list is not all-inclusive. The determination of whether an inspection can be conducted remotely is at the sole discretion of the AHJ.

- Plumbing system repairs or fixture replacements.
- Construction trailer installations.
- Swimming pool excavations.
- Gas line repairs or gas utility clearance.
- Electric utility clearances.
- HVAC direct replacement or repair.
- Minor residential electrical.
- Miscellaneous repair/exterior repair or upgrades (stucco, windows, etc.).
- Re-roofing/roof covering replacement.
- Water heater or water softener direct replacement.
- New residential plumbing rough-in.
- New residential rough framing inspections.
- Residential rooftop-mounted photovoltaic panel systems.
- HUD manufactured home installation verification.
- Any other inspection approved by the AHJ.

Recommended Practices for Remote Virtual Inspections (RVI)

Recommended Practices for Remote Virtual Inspections (RVI) is the most complete source of information on remote inspections. RVI is an alternative to on-site inspections using a video call on a 4G or WiFi telephony (smartphone, tablet, etc.) in order to interact with the inspector. It is a comprehensive tool for local jurisdictions and the building industry alike that desire to implement a remote inspection program.

This publication covers the RVI process, inspection scheduling, preparation, what the owner/contractor should expect, training and communications, and recording and maintaining records. While all types of inspections may not be suitable for RVI, a list of potential construction activities suitable for remote inspections is provided.

RVI also lends itself to connect seamlessly as part of an overall online program that will allow jurisdictions to provide complete services to the public utilizing the latest technology. Online permitting and electronic plan review, together with remote virtual inspections, can provide a complete program that keeps the construction industry moving while providing a healthy environment for all participants.

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Item No. 7072S1

TECH TIPS

TECH TIPS

insulation installation tips

insulation installation tips

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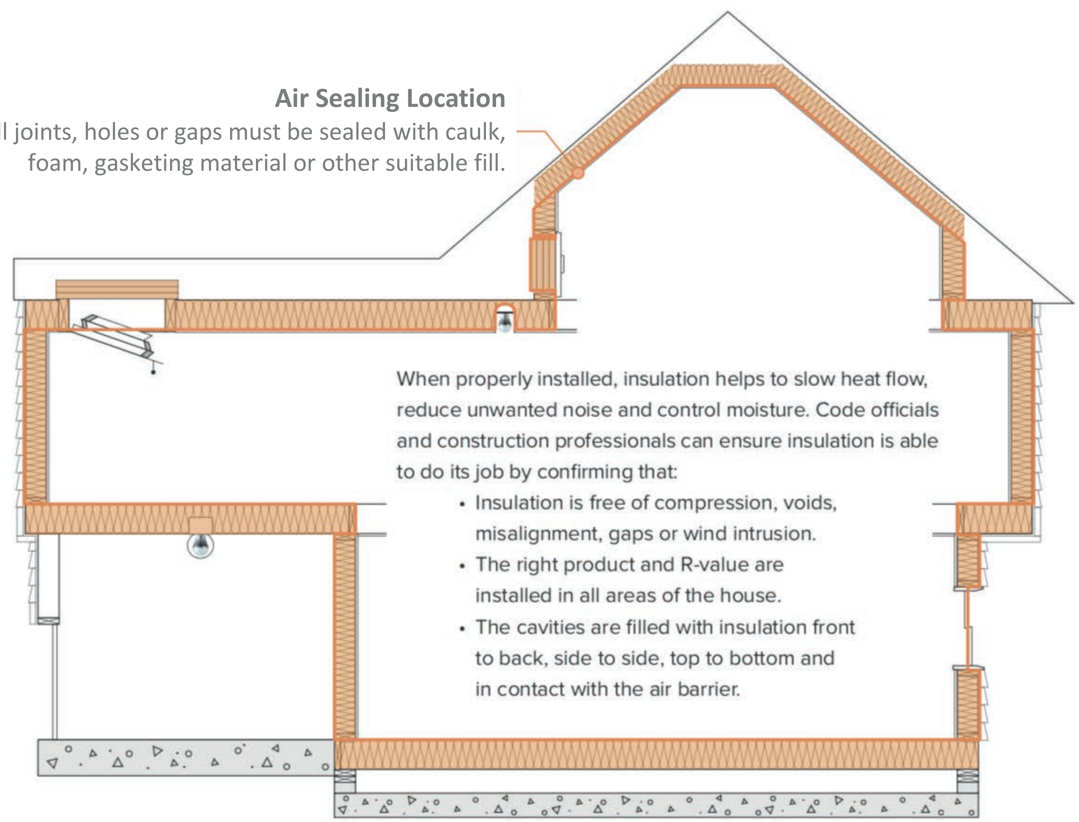
INSULATION INSTALLATION

Tips for Meeting Virginia Code

To meet the code-required R-values in Table 402.1.2, insulation must be installed per manufacturer's installation instructions. All manufacturers require that insulation be free of gaps, voids, misalignment, compression and wind intrusion.

Air Sealing Location
All joints, holes or gaps must be sealed with caulk, foam, gasketing material or other suitable fill.



When properly installed, insulation helps to slow heat flow, reduce unwanted noise and control moisture. Code officials and construction professionals can ensure insulation is able to do its job by confirming that:

- Insulation is free of compression, voids, misalignment, gaps or wind intrusion.
- The right product and R-value are installed in all areas of the house.
- The cavities are filled with insulation front to back, side to side, top to bottom and in contact with the air barrier.

Baseline Field Study Results

Ceiling Insulation R-Value
VA Code: R-38
96% COMPLIANT

Ceiling Insulation Quality
69% COMPLIANT

Grade I	Grade II	Grade III
69%	25%	6%

Wall Insulation R-Value
VA Code: R-15 or R-13 + 1
100% COMPLIANT

Wall Insulation Quality
37% COMPLIANT

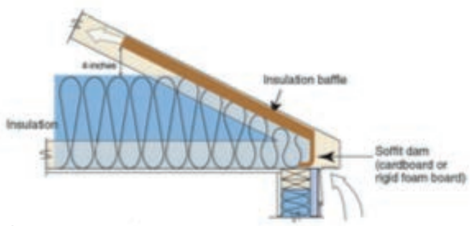
Grade I	Grade II	Grade III
37%	59%	4%

Grade 1: almost no gaps; Grade II: up to 2% gaps, compression or voids; Grade III: 2-5% gaps, compression or voids

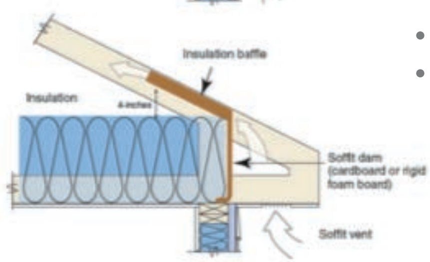
See [the Insulation, Air Barrier and Air Sealing Inspection Checklist]() to make sure code-compliance is achieved.

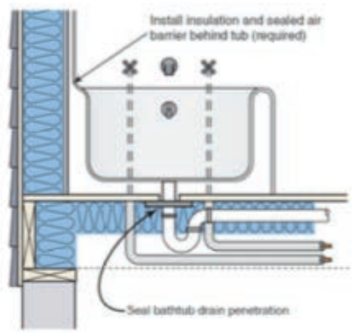
Example Details

Standard Truss with tapered insulation depth



Energy Truss with full height insulation (recommended)

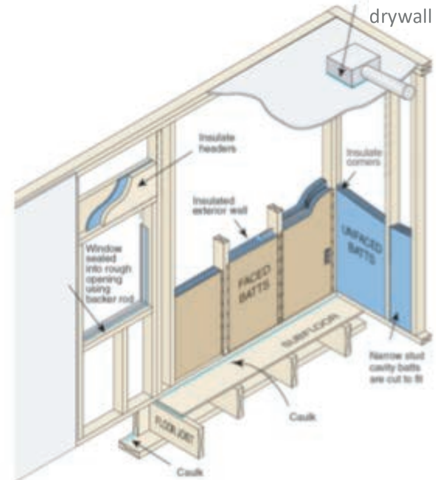




Inspecting Insulation

- Air sealing
- Baffling
- Obstructions
- Odd-sized cavities

Seal lights and bath vents fans to ceiling drywall

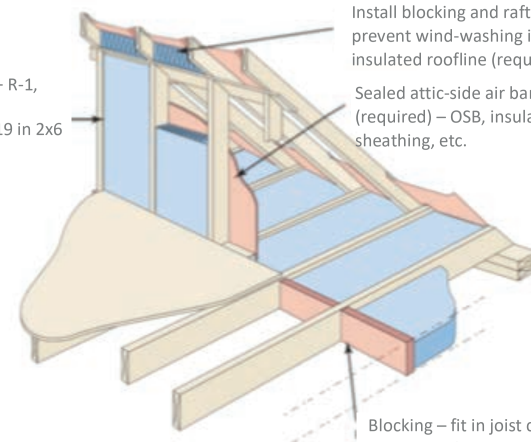


Inspecting Insulation

- Tubs
- Showers
- Fireplaces
- Attic knee walls

Options:

- R-13 + R-1,
- R-15,
- Or R-19 in 2x6



Install blocking and rafter baffle to prevent wind-washing if vented, insulated roofline (required)

Sealed attic-side air barrier (required) – OSB, insulated sheathing, etc.

Blocking – fit in joist cavity, caulked or foamed

Contact Viridiant with any questions or comments via: admin@viridiant.org or (804) 225-9843

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insulation tips

insulation tips

Success with the 2015 Virginia Construction Code

Tech Tips for Builders

INSULATION

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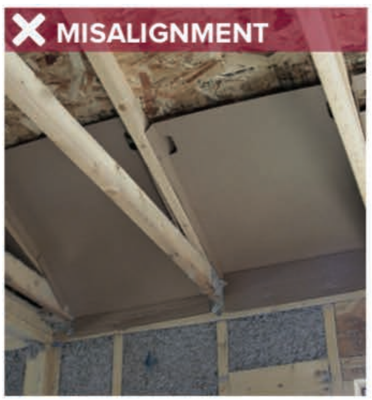
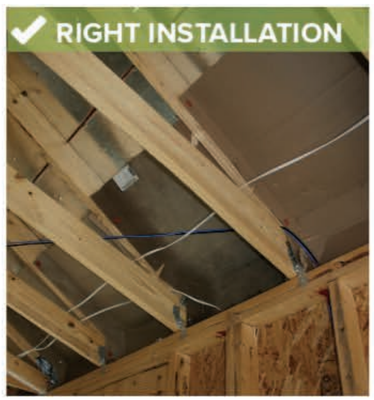
INSULATION

1. For vented attics, install wind baffles on top of all exterior walls, leaving room for at least 4 inches of insulation over top plates and ventilation above.





TECH TIPS:
INSULATION

2. Install insulation to meet the Virginia R-value requirements[a]. Insulation shall be installed in accordance with the manufacturer's instructions.

Climate Zone	Ceiling[b]	Frame Wall[c]	Slab	Basement/ Crawl Walls[d,e]	Mass Wall[f]	Floor[g]
Zone 4	R-38	R-15 or 13+1	R-10, 2 ft	R-10/13	R-8/13	R-19

a. R-values are minimums. When insulation is installed in a cavity which is less than the label or design thickness of the insulation, the installed R-value shall not be less than the R-value specified in the table.
b. For air-permeable insulation in vented attics, a baffle shall be installed adjacent to the soffit and eave vents. The baffle shall maintain an opening equal or greater than the size of the vent and extend over the top of the attic insulation.
c. R-values noted are for wood framed walls. R-13 cavity + R-1 insulated sheathing or R-15 cavity will meet the requirement. For kneewalls, the attic side shall have a sealed air barrier.
d. R-10 is continuous and R-13 is cavity.
e. Basement walls shall be insulated from the top of the basement wall down to 10 feet below grade or the basement floor, whichever is less.
f. The second R-value applies when more than half the insulation is on the interior side of the mass wall.
g. Floor insulation shall be installed to maintain continuous permanent contact with the underside of the subfloor decking, and insulation ends shall have air barriers.

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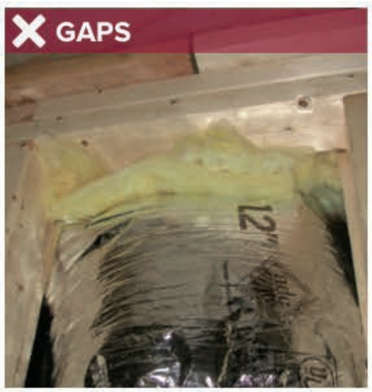
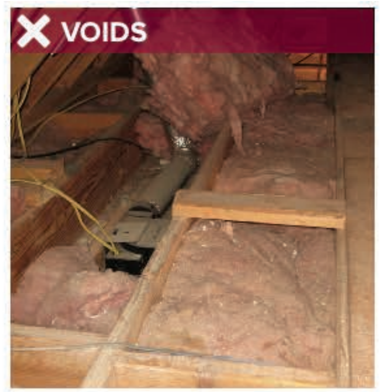
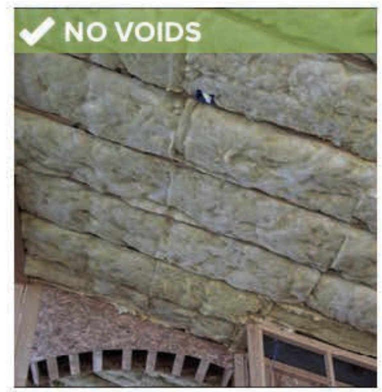
INSULATION

3. Install insulation to fill the cavity between conditioned and unconditioned space without gaps, voids, misalignments or compression.







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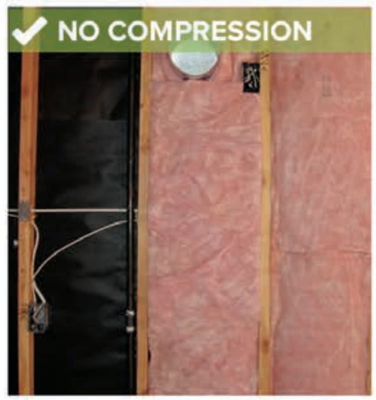
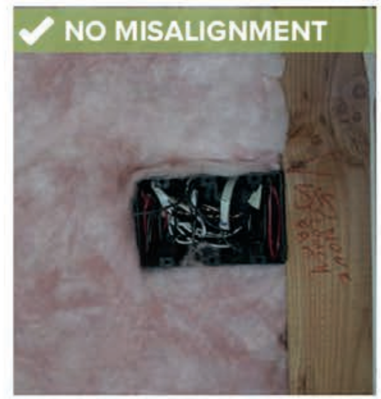
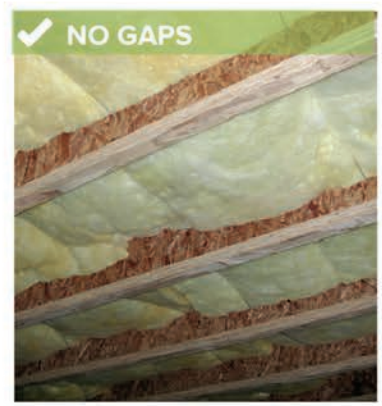
TECH TIPS:
INSULATION

4. Cut and split insulation around blocking, plumbing, HVAC and electrical components.





5. Install insulation to completely fill floor framing or to maintain permanent contact with the subfloor.



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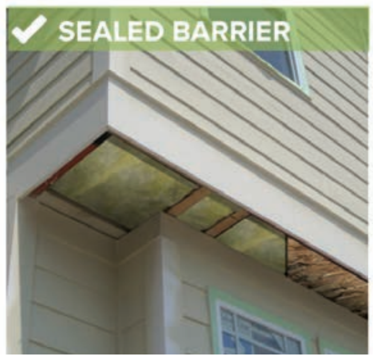
TECH TIPS:
INSULATION

6. For cantilever floors, frame to allow for at least R-19 and encapsulated with an exterior rigid air barrier and air sealing.

7. Air seal around windows and doors using backer rod, caulk or low expansion foam.



8. Insulate the attic access and install weather stripping around the perimeter.

TECH TIPS:
INSULATION

9. For attics with loose fill insulation, install baffles around the attic access opening.

lighting tips

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LIGHTING

Tips for Meeting Virginia Residential Energy Code

The lighting industry has been transformed by compact fluorescent lamp (CFL) and light-emitting diode (LED) technologies because of their high performance and energy efficiency. Not only should CFLs and LEDs be considered for building lighting solutions, but N1104.1 (R404.1) of the 2015 Virginia Residential Code requires that at least 75% of the permanently installed lighting fixtures contain only high-efficacy lamps or that 75% of the lamps in permanently installed fixtures be high-efficacy.

The visual below shows the common way to meet the code for lighting equipment: using CFLs and/or LEDs for at least 75% of a home's bulbs.

LED

CFL

≥ 75%

Combination of both

Incandescent

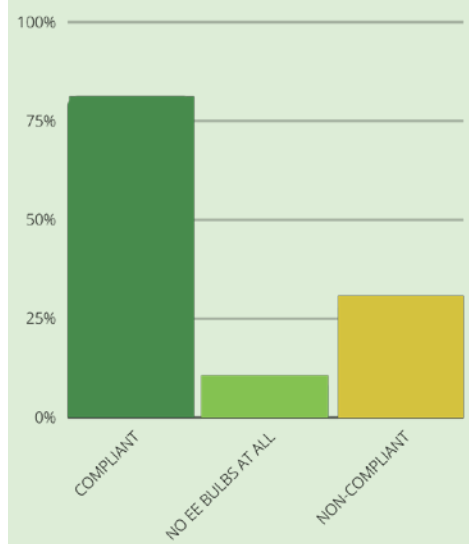
≤ 25%

Incandescents

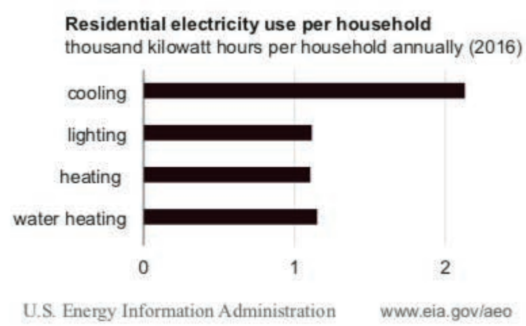
Baseline Field Study Results

High-Efficacy Lighting

2017-2018 Virginia Residential Field Study results



Enforcing lighting code requirements is important and easy to do:



800 Lumens	60W	14W	13W
Avg. 20-year cost	$326	$88	$61
# of bulbs per location	23	3	1
	NON-COMPLIANT	COMPLIANT	COMPLIANT

Note: Cost comparison is based on a 20-year life and takes into account power consumption, hours of use per day, residential electricity cost, bulb cost and replacement cost. For detailed cost calculations and a full pro/con list, visit http://Lighting.MnCERTs.org

LEARN MORE AT energystar.gov

MAKE LIGHTING INSPECTIONS EASIER:

- Look for the ENERGY STAR label
- Use a **lighting ballast discriminator,** an electronic sensor that indicates if lighting is energy efficient.

A lighting ballast discriminator can detect the frequency of a bulb's ballast with the simple push of a button, telling you what type of bulb is present. A green light indicates a CFL or an LED, while a red light indicates an incandescent.

Contact Viridiant with any questions or comments via: admin@viridiant.org or (804) 225-9843

DUCT SEALING + TESTING

DUCT SEALING + TESTING

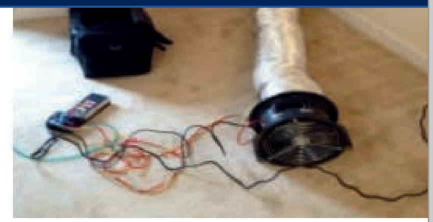
inspection guide

inspection guide

Duct Sealing and Testing

2015 IECC (w/ Amendments) Inspection Guide





Duct Testing and Sealing:

Summary: New to Virginia with the 2015 Code Cycle is Mandatory testing of ducts, requiring 4% Duct Leakage based on Conditioned Floor Area (CFA) or less. This guide is intended to give both code and real world examples of what that change means for code enforcement in the Commonwealth.

Why: Consistent enforcement of the 2015 Duct Leakage provisions within the code will save the occupants of the roughly 20,000 new homes built each year a combined $1.24 Million on an annual basis. (Figure 1).[1] According to the Building America Solutions Center, "Duct leakage is a double hit on the utility bill: 1) duct leaks are an uncontrolled loss of conditioned air to the outdoors and 2) duct leakage drives building infiltration. For example, if a home had a 2.5-ton (30,000 BTU/H) cooling system moving 1,000 CFM (cubic feet per minute) of air and the ducts had 10% leakage (which is typical in code-built homes), the leakage rate would be 100 CFM. Each cubic foot of air carries with it 30 BTUs/H, so 3,000 BTUs of conditioned air would be lost to the outdoors each hour."[2] In addition to monetary and energy concerns, uncontrolled infiltration can have large health and durability impacts.

Measure	Total Energy Savings (MMBtu)	Total Energy Cost Savings ($)	Total State Emissions Reduction (MT CO2e)
Duct Leakage	6,4168	1,244,243	31,520

Figure 1: Estimated Annual Statewide Savings Potential

If any component of an HVAC System is located outside of the building's thermal envelope, the system will be required to be pressure tested to determine air leakage. This test can take place at Rough-In or after HVAC Trim Out has been completed. There are differing standards for leakage based on what components are installed during the time of the test.

- 3 Cubic Feet per Minute (CFM) / 100 Sq. Ft. of Floor Area Served (or 3% of CFA at rough-in without the air handler installed
- 4 Cubic Feet per Minute (CFM) / 100 Sq. Ft. of Floor Area Served (or 4% of CFA at rough-in with the air handler installed or at final)

$$\text{Duct Leakage} = \frac{\text{cfm}_{25}}{\text{square ft. of floor area served (CFA)}}$$

[1] https://www.energycodes.gov/sites/default/files/documents/Virginia_Residential_Field_Study.pdf
[2] https://basc.pnnl.gov/resource-guides/sealed-and-insulated-flex-ducts#edit-group-description

Anyone that has been substantially trained on the duct testing equipment is able to perform duct leakage testing per Virginia Code.

Determining the necessity of Duct Testing

1. Determine Location of HVAC Systems within the home:
    a. Are all Ducts located within a Crawl Space/Attic/Between Floor/Dropped Ceiling?
        i. If 'Yes'
            1. Do drawings indicate these locations to be within the Building's Thermal Envelope (**Section R403.3.7**)
            2. If Yes – No Testing Required
        ii. If 'No'
            1. Duct testing is required
2. If duct testing is required, the square feet each system being installed is serving must be determined in order to understand necessary duct leakage targets.
    a. Ex) 1 system serving the entire home. Conditioned floor area of the home is 1,200 sq. ft.

    4% of conditioned floor area = **1,200 X 0.4 = 48**

    To pass final duct leakage at final inspection: **CFM_{25} must be ≤ 48 CFM**

    A written report of the results of the test shall be signed by the party conducting the test and provided to the Code Official. Check to ensure all systems are at or below required duct leakage based on floor area served.

Notes:

- *Duct boot to drywall and duct boot to subfloor connections are typically the largest offenders for total leakage, including returns boot connections to drywall*
- *Duct boots can be easily covered by drywall and lead to higher leakage in the field*
- *Ventilation systems connected to the central Heating and Cooling system can also increase leakage if not operating properly*
- *Based on the Virginia Residential Energy Code Field Study results, 94% of systems tested were over the upcoming 4 cfm/100 sq ft threshold, with that dropping to an 84% failure rate with the conditioned space exemption applied*
- *Duct leakage drives infiltration, or air leakage, through the envelope; it can negatively or positively pressurize the house depending on where the ducts are leaking, pulling outside air in through cracks in the building envelope or pushing conditioned air out. If the duct leakage is in the supply-side ducts, the house will be negatively pressurized compared to outdoors. If all the leakage is on the return side, the building will be positive with respect to outdoors*[3]

[3] https://basc.pnnl.gov/resource-guides/sealed-and-insulated-flex-ducts#edit-group-description

Duct Sealing Visual:

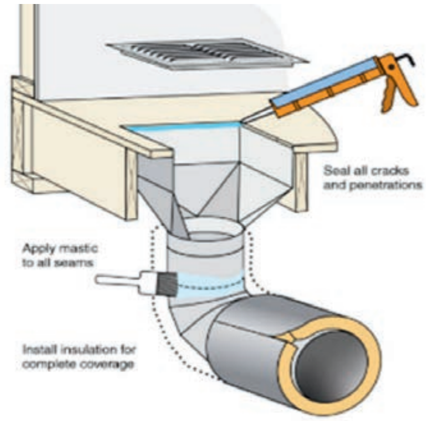


Figure 1: Joints and Seams at Duct Boot Sealed

Figure 2: Increased duct and envelope leakage if left unsealed

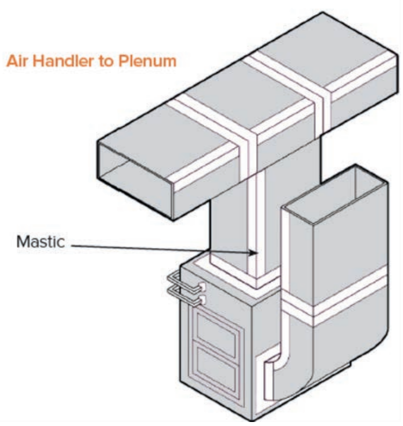


Figure 3: Well sealed plenum and trunk

Figure 4: Well sealed supply-to-trunk connection

Figure 5: Unsealed tabular duct takeoff

Figure 6: Unsealed and poorly supported duct takeoff

Figure 7: Mastic paste used as permanent seal – “thick as a nickel”

Duct Testing Code Reference:

Section R403.3.3/N1103.3.3 Duct testing (mandatory). Ducts shall be pressure tested 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 water gage (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 water gage (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 where the ducts and air handlers are located entirely within the *building thermal envelope*.

A written report of the results of the test shall be signed by the party conducting the test and provided to the code official. The licensed mechanical contractor installing the mechanical system shall be permitted to perform the duct testing. The contractor shall have been trained on the equipment used to perform the test.

Section R403.3.4/N1103.3.4 Duct Leakage (Prescriptive). The total leakage of the ducts, measured in accordance with Section R403.3.3/N1103.3.3, shall be as follows:

1. ***Rough-in test.*** The total leakage shall be less than or equal to 4 cubic feet per minute (113.3 L/min) per 100 square feet (9.29 m2) 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 (85 L/min) per 100 square feet (9.29 m2) of conditioned floor area.
2. ***Post-Construction test.*** Total leakage shall be less than or equal to 4 cubic feet per minute (113.3 L/min) per 100 square feet (9.29 m2) of conditioned floor area.

Duct Sealing Code Reference:

Section R403.3.2/N1103.3.2 Sealing (Mandatory). Ducts, air handlers and filter boxes shall be sealed. Joints and seams shall comply with the International Mechanical Code or International Residential Code where applicable.

Exceptions:

1. Air-impermeable spray foam products shall be permitted to be applied without additional joint seals.

2. 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 of other than the snap-lock and button-lock types.

Section R403.3.2.1/N1103.3.2.1 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 in accordance with ASHRAE 193

Duct Location Code Reference:

Section R403.3.5/N1103.3.5 Building Cavities (mandatory). Building framing cavities should not be used as ducts or plenums.

Definitions:

Building Thermal Envelope: The basement walls, exterior walls, floor, roof and any other building elements that enclose conditioned space or provide a boundary between conditioned space and exempt or unconditioned space

Conditioned Space: An area, room or space that is enclosed within the building thermal envelope and that is directly heated or cooled or indirectly heated or cooled

Above-Grade Wall: A wall more than 50% 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 mansard roof and skylight shafts

Air Barrier: Material(s) assembled and joined together to provide a barrier to air leakage through the building envelope. An air barrier may be a single material or a combination of materials

R-Value: Resistance to Heat Flow of a single material, expressed as a whole number. Higher numbers denote higher resistance to heat flow

U-Value: Resistance to heat flow of multiple materials expressed as a decimal point. Lower numbers denote higher resistance to heat flow

Infiltration: The uncontrolled inward air leakage into a building caused by the pressure effects of wind, or the effect of differences in the indoor and outdoor air density or both

report form

report form

Duct Test Report

Testing Company	Name of Tester	Signature

Home Address	Permit Number	GPIN
Conditioned Square footage	**Source of Conditioned Square Footage**	**Number of HVAC Systems**

TEST RESULTS

System 1

Duct tightness testing is not required. All ducts and the air handler are located entirely within the building thermal envelope.

Square Footage Served	Test Conditions	Maximum Allowed (CFM25)	Photo of Test Results on Gauge
Date	**Test results (cfm@25pa)**	**Compliance Status**	

System 2

Duct tightness testing is not required. All ducts and the air handler are located entirely within the building thermal envelope.

Square Footage Served	Test Conditions	Maximum Allowed (CFM25)	Photo of Test Results on Gauge
Date	**Test results (cfm@25pa)**	**Compliance Status**	

Notes

N1103.3.4 (R403.3.4) Duct Leakage (Prescriptive)

Test Conditions	Maximum Allowed Duct Leakage	Maximum Allowed (CFM25)
Rough-in with air handler installed	4 CFM per 100 sq ft of conditioned floor area	.04 x conditioned floor area served
Rough-in without air handler installed	3 CFM per 100 sq ft of conditioned floor area	.03 x conditioned floor area served
Post-construction	4 CFM per 100 sq ft of conditioned floor area	.03 x conditioned floor area served

INSPECTION + PLAN REVIEW

INSPECTION +
PLAN REVIEW

indoor air quality

Indoor Air Quality, Code and COVID

Improving Indoor Air Quality in New Construction Homes built under the 2015 Virginia USBC

Although improvements to ventilation and air cleaning cannot on their own eliminate the risk of airborne transmission of the SARS-CoV-2 virus, the **Environmental Protection Agency (EPA) recommends increasing ventilation with outdoor air and air filtration** as important components of a larger strategy that includes social distancing, wearing cloth face coverings or masks, surface cleaning and disinfecting, hand washing, and other precautions.

VENTILATION

- Bring in Fresh Air
  - Install operable windows
  - Provide mechanical ventilation using a supply (positive pressure) strategy or
  - Provide mechanical ventilation using an Energy Recovery Ventilator (ERV)
- Exhaust Stale and Polluted Air
  - Remove air from the house with bathroom exhaust fans. Adding timer controls allows occupants flexibility with the run times.
  - Install vented range hoods. Reduces pollution from cooking activities, providing better overall indoor air quality.

FILTRATION

- Properly sized HVAC systems have longer run times, leading to more air being filtered.
- EPA recommends a MERV 13 filter, which traps smaller particles, including viruses. Ensure that the installed HVAC system is compatible with a MERV 13 filter.
- Ensure the filter fits properly. Air that can move past it (instead of through it) will not be filtered.
- Provide instructions to the occupants on how often the filter should be changed, what size to get, and what MERV rating.

HVAC Filter Effectiveness

MERV	Dust/Lint	Dust Mites	Pollen	Mold	Pet Dander	Bacteria	Attached Viruses
1-4	✓	✓	✓				
5-7	✓	✓	✓	✓			
8-12	✓	✓	✓	✓	✓	✓	
13-16+	✓	✓	✓	✓	✓	✓	✓

CODE

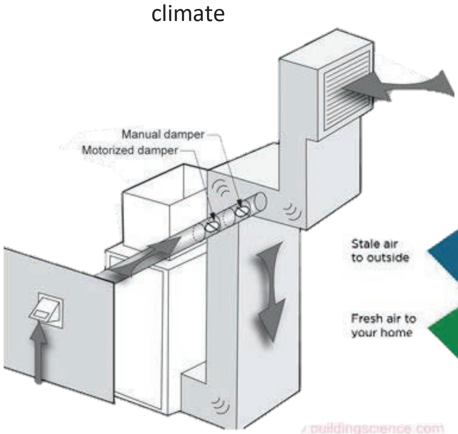
Mechanical ventilation is required in the 2015 Residential Energy Code and is achievable through three strategies. The code reads:

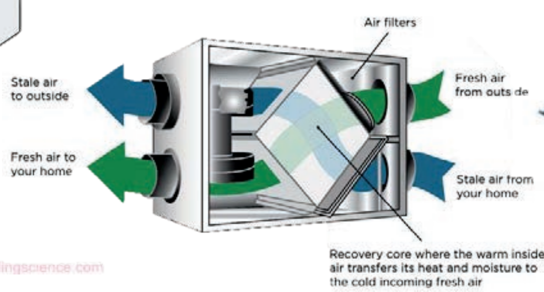
> ***Section R403.6 Mechanical Ventilation (mandatory)***
> *The building shall be provided with ventilation that meets the requirements of the International Residential Code or International Mechanical Code, as applicable, or with other approved means of ventilation. Outdoor air intakes and exhausts shall have automatic or gravity dampers that close when the ventilation system is not operating.*

Ventilation Strategies

Various ventilation strategies may be used to meet mechanical ventilation including:

- **Exhaust** or negative pressure exhaust often via bathroom exhaust ventilation utilizing timed settings to control exhaust ventilation
- **Supply** or positive pressure of fresh air introduced and most commonly circulated through air handler using an electronically controlled motor
- **Balanced** ventilation where amount of air brought in or supplied is approximately equal to the amount of air exhausted, most commonly via an energy recovery ventilator in our climate





How much air is required?

The rate of ventilation is measured in Cubic Feet per Minute (CFM) and the amount of designed continuous ventilation is determined by home size (square feet) and number of bedrooms (e.g. assumed number of occupants). If using an intermittent or non-continuous ventilation strategy, the design ventilation is increased by an adjustment factor. (Source: Virginia Residential Code Table M1507.3)

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

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inspection checklist

inspection checklist

Insulation, Air Barrier and Air Sealing Inspection Checklist

Virginia 2015 IECC (w/ Amendments) Inspection Guide

Address: ______________________ **Permit #:** ________

Inspector: ______________________ **Date:** ________

Builder:

Complete	Air Sealing: Component/Inspection Point	N/A	Notes:
☐	All gaps, cracks, seams, and penetrations between conditioned and unconditioned space (i.e. gaps around lighting fixtures, HVAC duct boots, electric wiring, plumbing pipes, and flues) shall be sealed with sealants alone (e.g., caulk, foam, aerosol sealant) or, for larger gaps, with rigid blocking material (e.g. backer rod) sealed in place with sealants, per sealant manufacturer's instructions. Fibrous insulation is NOT an air barrier and shall not be used for air sealing	☐	
☐	The space between window/door jambs and framing, and skylights and framing shall be sealed. Fibrous insulation is not an air barrier and shall not be used for air sealing	☐	
☐	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	☐	
☐	Seams where drywall attaches to the top plate at all interior and exterior walls shall be sealed from the attic side with a caulk, spray foam, or sprayer-applied sealant	☐	
☐	Larger gaps and openings (such as uncovered dropped soffits and openings under knee walls or at the tops of balloon-framed gable walls) shall be closed off using a solid material such as rigid foam or OSB that is sealed at the edges with caulk, sealant, or mastic	☐	
☐	Gaps around masonry chimneys or gas appliance vents shall be sealed with high-temperature-rated caulk or foam in accordance with building code requirements	☐	
☐	A continuous gasket, such as weather stripping, shall be installed around all exterior door openings	☐	
☐	Recessed lighting fixtures installed in the building thermal envelope shall be air tight and IC rated	☐	
☐	Air sealing shall be provided between the garage and conditioned spaces	☐	

Notes:

Complete	Wall Insulation, Air Barrier and Air Sealing	N/A	Notes:
☐	A continuous air barrier shall be installed in the building envelope. The exterior thermal envelope contains a continuous air barrier	☐	
☐	Insulation installed to be in full contact with the air barrier (the Sheetrock to the inside and the sheathing to the outside). If the insulation is not encapsulated by a rigid material on all six sides, it WILL NOT insulate properly	☐	
☐	Insulation is installed to fill 100 percent of cavity	☐	
☐	If batts are installed, the batt is cut to fit around all plumbing, heating and electrical penetrations and other obstacles. It is split to go behind and in front of wires and plumbing. This is done in such a way as to fill all cavity spaces and gaps, while *not* compressing the insulation	☐	
☐	Batts in narrow cavities shall be cut to fit, or narrow cavities shall be filled by insulation that, on installation, readily conforms to the available cavity space	☐	
☐	Walls are framed to allow the corner to be insulated or continuous insulation is/will be installed	☐	
☐	Exterior walls adjacent to showers and tubs shall be insulated	☐	
☐	The air barrier installed at exterior walls adjacent showers and tubs shall separate the tub/shower from the exterior wall and be air sealed	☐	
☐	The air barrier shall be installed behind electrical or communication boxes or air-sealed boxes shall be installed	☐	

☐	Crawl space walls: Where provided instead of floor insulation, insulation shall be permanently attached to crawlspace walls	☐	
☐	Rim joists: Rim joists shall be insulated	☐	
☐	When utilized: exterior thermal envelope insulation for framed walls shall be installed in substantial contact and continuous alignment with the air barrier	☐	
Notes:			

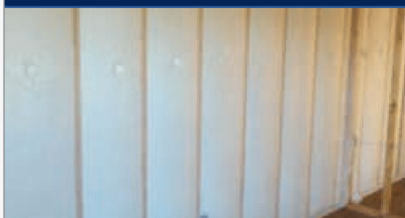
Complete	Attic Insulation, Air Barrier and Air Sealing	N/A	Notes:
☐	Before installing fibrous attic floor insulation, baffles shall be installed at all attic eaves adjoining vented soffits to prevent air flow through the insulation and to provide a path for ventilation air from the soffit vents to the ridge vents. The baffles shall extend at least 6 inches above the height of the attic insulation	☐	
☐	Attic insulation extends all of the way to the exterior edge of the top plate of the wall below without compression. Roof-framing details, such as raised-heel trusses or oversized trusses, must allow for this	☐	
☐	R-19 insulation shall be installed at attic knee walls, skylight shaft walls, vertical portions of all dropped ceilings, and any other vertical wall adjoining conditioned space	☐	
☐	The air barrier in any dropped ceiling/soffit shall be aligned with the insulation and any gaps in the air barrier shall be sealed	☐	
☐	All joints, cracks, and penetrations in the wall air barrier shall be fully sealed with caulk, foam, or equivalent	☐	
☐	Attic insulation shall be installed at all flat and sloped surfaces adjoining the conditioned space with less than 2% gaps, voids, and compressions and at levels that meet or exceed prescriptive levels specified by the 2015 Virginia Energy Conservation Code	☐	
☐	All attic insulation shall be uniform and conform to manufacturer-specified density with attic rulers to verify full depth	☐	
☐	Attic access panels, doors, and drop-down stairs shall be insulated with a minimum of R-5 rigid foam insulation and gasketed (not caulked) to provide a continuous air seal when closed	☐	
☐	All non-ICAT recessed light fixtures shall be boxed with a solid material, such as drywall or rigid foam, that is sealed at all seams with a sealant such as caulk, mastic, or spray foam	☐	
☐	Sprinklers: When 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.	☐	

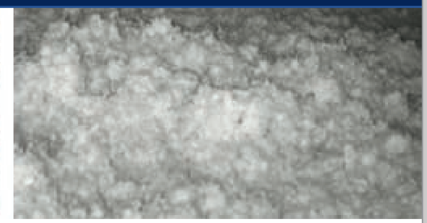
Complete	Floor Insulation, Air Barrier and Air Sealing		
☐	Floor framing cavity insulation shall be installed to maintain permanent contact with the underside of subfloor decking, or floor framing cavity insulation shall be permitted to be in contact with the top side of sheathing, or continuous insulation installed on the underside of floor framing and extends from the bottom to the top of all perimeter floor framing members	☐	
☐	Air barrier shall be installed at any exposed edge of insulation	☐	
☐	Exposed earth in unvented crawl spaces shall be covered with a Class I vapor retarder with overlapping joints taped	☐	
Notes:			

insulation / air barrier

Insulation & Air Barrier

Virginia 2015 IECC (w/ Amendments) Inspection Guide





Insulation and Air Barrier:

Summary: The thermal envelope is the most important system relating to the performance of the home. Properly aligned air barrier and thermal insulation systems provide long lasting benefits to both the home and its occupants. Thermal components of the building's thermal envelope, Per N1101.5.1, envelope must be represented on the construction drawings.

Why: Poorly installed insulation can result in higher heating and cooling costs, comfort problems, mold, and other moisture related issues including long-term durability and structural issues. Professionally installed insulation meets industry best practices as specified for Grade 1 installation by the Residential Energy Services Network (RESNET). This includes no gaps, voids, compression, or misalignment with air barriers; complete air barriers; and minimal thermal bridging. Following best practices for insulation installation creates conditioned spaces that require very little heating and cooling, along with even temperatures and a quieter environment throughout the house.[1]

Per RESNET, "When installing batt, or loose-fill insulation, no more than 2% of the total insulated area shall be compressed below the thickness required to attain the labeled R-Value or contain gaps or voids in the insulation. These areas shall not be compressed more than 3/4 inch of the specified insulation thickness in any given location. Voids extending from the interior to exterior of the intended insulation areas shall not be permitted."[2] An important distinction between manufacturer recommendations, as stated in code, and RESNET Grade 1, is that RESNET Grading allows for minor defects while manufacturers recommended install **does not**.

Notes:

- *Specific Blown Fiberglass systems, High Density Fiberglass/Mineral Wool Batts, and Spray Foam Insulation are materials typically used in wall assemblies that can achieve R-15 in a 2x4 stud cavity. Most other products will need to be installed in conjunction with exterior continuous insulation and/or installed in a 2x6 Wall Assembly.*
- *In order to be effective, Insulation must be continuous and contiguous. All insulated surfaces – ceilings, walls, and floors – must be insulated and in contact with one another.*

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[1] https://basc.pnnl.gov/building-science-measures/insulation-quality-installation

[2] https://www.resnet.us/wp-content/uploads/ANSIRESNETICC-301-2014-Addendum-F-2018-Appendix-A-Inspection-Procedures-for-Insulation-Grading-and-Assessment.pdf

* *Most common insulation materials work by slowing conductive heat flow and--to a lesser extent--convective heat flow. Radiant Barriers and reflective insulation systems work by reducing radiant heat gain. To be effective, the reflective surface must face an air space.*[3]
* *Heat flows from hot to cold until and will do so until there is no longer a temperature difference. In practice, this means that in winter, heat flows directly from heated living spaces to adjacent unheated attics, garages, basements, and the outdoors. Heat flow can also move indirectly through interior ceilings, walls, and floors--wherever there is a difference in temperature. Poor insulation installation will lead to increased heat flow into/out of the building..*

Visual Reference:

TABLE R402.1.2 INSULATION AND FENESTRATION REQUIREMENTS BY COMPONENT[a]

CLIMATE ZONE	FENESTRATION U-FACTOR[b]	SKYLIGHT[b] U-FACTOR	GLAZED FENESTRATION SHGC[b, e]	CEILING R-VALUE	WOOD FRAME WALL R-VALUE	MASS WALL R-VALUE[i]	FLOOR R-VALUE	BASEMENT[c] WALL R-VALUE	SLAB[d] R-VALUE & DEPTH	CRAWL SPACE[c] WALL R-VALUE
1	NR	0.75	0.25	30	13	3/4	13	0	0	0
2	0.40	0.65	0.25	38	13	4/6	13	0	0	0
3	0.35	0.55	0.25	38	20 or 13+5[h]	8/13	19	5/13[f]	0	5/13
4 except Marine	0.35	0.55	0.40	38	15 or 13+1[h]	8/13	19	10 /13	10, 2 ft	10/13
5 and Marine 4	0.32	0.55	NR	49	20 or 13+5[h]	13/17	30[g]	15/19	10, 2 ft	15/19
6	0.32	0.55	NR	49	20+5 or 13+10[h]	15/20	30[g]	15/19	10, 4 ft	15/19
7 and 8	0.32	0.55	NR	49	20+5 or 13+10[h]	19/21	38[g]	15/19	10, 4 ft	15/19

Table 1: Table R402.1.2 from Virginia Residential Energy Code, Chapter 4[4]

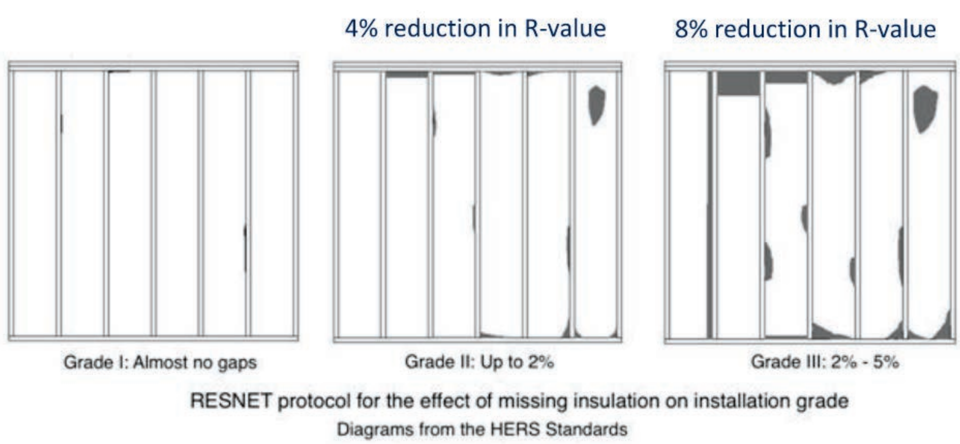

Figure 1: RESNET Insulation Grading Diagram

[3]https://www.energy.gov/energysaver/weatherize/insulation#:~:text=Insulation%20in%20your%20home%20provides,costs%2C%20but%20also%20improves%20comfort.
[4] https://codes.iccsafe.org/content/VECC2015/chapter-4-re-residential-energy-efficiency

Figure 2: Various examples of good and bad installations

Figure 3: Insulated floor over garage

Figure 4: Blown cellulose insulation installation

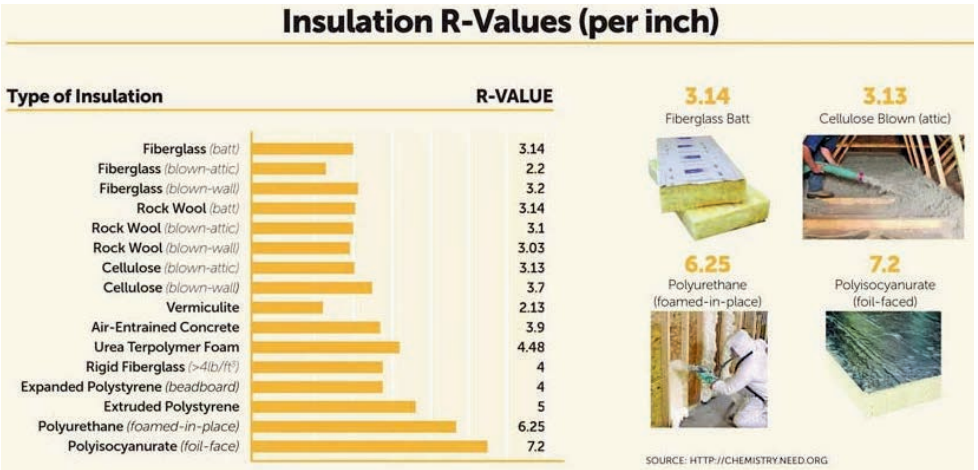

Figure 5: R-Value per inch tables

Insulation Installation Code Reference:

Section R402.4.1/N1102.4.1 Building Thermal Envelope. The building thermal envelope shall comply with Sections R402.4.1.1 and R402.4.1.2. The sealing methods between dissimilar materials shall allow for differential expansion and contraction.

Section R402.4.1.1/N1102.4.1.1 Installation (Mandatory). The components of the building thermal envelope as listed in Table R402.2.1.1(N1102.4.1.1) shall be installed in accordance with the Manufacturer's instruction and the criteria listed in Table R402.2.1.1(N1102.4.1.1), as applicable to the method of construction. Where required by the code official, an approved third party shall inspect all components and verify compliance.

Section R402.4.1.3/N1102.4.1.3 Leakage Rate (Prescriptive). The building or dwelling unit shall have an air leakage rate less than 5 changes per hour as verified in accordance with Section N1102.4.1.2.

Section R402.4.1.2.1(N1102.4.1.2.1) & R402.4.1.2.2(N1102.4.1.2.2) provides the compliance options for air sealing – Testing via blower door or Visual Inspection.

Section R303.1.1/N1101.10.1 An R-value identification mark shall be applied by the manufacturer to each piece of building thermal envelope insulation 12 inches or greater in width. Alternately, the insulation installers shall provide a certification listing the type, manufacturer and R-Value of insulation installed in each element of the building thermal envelope.

Section R303.1.1.1/N1101.10.1.1 Blown or sprayed roof/ceiling insulation. The thickness of blown-in or sprayed roof/ceiling insulation (fiberglass or cellulose) shall be written in inches on markers that are installed at least one for every 300 sq. ft.

Section R303.2/N1101.11 Installation. All materials, systems and equipment shall be installed in accordance with the manufacturer's instruction and this code.

Section R303.2.1/N1101.11.1 Protection of exposed foundation insulation. Insulation installed on exterior foundation walls should have a rigid, opaque, and weather-resistant covering that covers the exposed insulation and extends 6 inches below grade to prevent degradation.

Retrofit
Section R501.1.1/N1107.1.1 Additions, alteration, or repairs: General. Additions, alterations, or repairs to an existing building or portion thereof shall comply with Section N1108, N1109 or N11010. Unaltered portions of the existing building or building supply system shall not be required to comply with this chapter.

**Note: Alterations, repairs, etc. are able to comply with the VEBC if so desired by the applicant.*

Insulation Installation Field Inspection Focus:

Inspections should provide verification in the following areas:[5]

1. Cavity insulation, as indicated in approved construction documents, completely fills ALL wall cavities with no compression or gaps, the manufacturer's R-value mark is readily available, and meets the approved R-value per construction documents.
2. Continuous insulation (if applicable) is installed in accordance with manufacturer's installation instructions, the manufacturer's R-value mark is readily available, and meets the approved R-value per construction documents.
3. Batt insulation is cut neatly around any wiring and plumbing, or insulation readily conforms to available space and extends behind piping and wiring.
4. Joints, seams, holes, and penetrations are caulked, gasketed, weather-stripped, or otherwise sealed.
5. Continuous air barrier is properly installed as indicated in approved construction documents. Confirm the insulation is installed in substantial contact and continuous alignment with the air barrier.
6. The junction where the rafters meet the exterior wall top plates and/or the attic floor are sealed.

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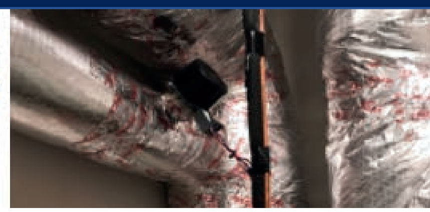
[5] https://basc.pnnl.gov/code-compliance/air-sealing-and-insulating-attic-knee-walls-code-compliance-brief

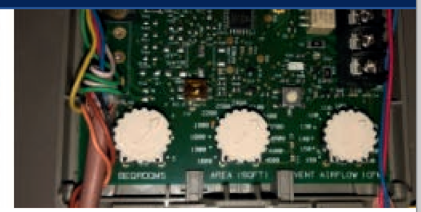
fresh air ventilation

fresh air ventilation

Whole-House Ventilation

2015 IECC (w/ Amendments) Inspection Guide





2015 Whole-House Ventilation Code Requirements:

Summary: The 2015 Virginia Residential Code requires Mechanical Ventilation be provided to new homes. Whole-house mechanical ventilation operates continuously or intermittently where the system has controls that enable operation for not less than 25-percent (25%) of each four (4) hour segment. The intent of these systems is to provide ongoing delivery of controlled, ideally filtered, fresh air to the living space, expel stale air, and dilute potential contaminants and improve indoor environmental quality.

Why: More people are working from home than ever and an even greater emphasis is being placed on indoor environmental quality. Whole-house ventilation is fundamentally concerned with the health and well-being of the occupants. It is estimated that people spend up to 90% of their time indoors. To maintain healthy, productive indoor environments, homes need a controlled means of bringing in fresh air and removing stale air on a regular schedule to ensure some dilution of contaminants and dissipation of odors.[1] There are several strategies commonly used to bring in whole-house ventilation: supply, exhaust, and energy recovery ventilation. Depending on the strategy and product utilized, fresh air systems consist of air intake (**Code Sections: M1602.1, M1602.2**) and outlet vents, filters, ducts, controls, and fans (**Code Section: R403.6.1**). The strategy and system chosen should take into account exterior temperature variations, desired indoor and prevalent outdoor humidity conditions, house configuration, and design objectives for the quantity and quality of air delivered.[2] Each system has its advantages and disadvantages – see the table below for more information.

Ventilation System	Pros	Cons
Exhaust	• Relatively inexpensive and simple to install • Work well in cold climates.	• Can draw pollutants into living space • Not appropriate for hot humid climates • Rely in part on random air leakage • Can increase heating and cooling costs • May require mixing of outdoor and indoor air to avoid drafts in cold weather • Can cause back drafting in combustion appliances.
Supply	• Relatively inexpensive and simple to install	• Can cause moisture problems in cold climates

[1] https://basc.pnnl.gov/building-science-measures/dilution-whole-house-ventilation
[2] https://basc.pnnl.gov/building-science-measures/properly-installed-whole-house-ventilation

Supply (cont'd)	• Allow better control than exhaust systems • Minimize pollutants from outside living space • Prevent backdrafting of combustion gases from fireplaces and appliances • Allow filtering of pollen and dust in outdoor air • Allow dehumidification of outdoor air • Work well in hot or mixed climates.	• Will not always temper or remove moisture from incoming air • Can increase heating and cooling costs • May require mixing of outdoor and indoor air to avoid drafts in cold weather.
Energy Recovery & Heat Recovery Ventilators	• Reduce heating and cooling costs • Available as both small wall- or window-mounted models or central ventilation systems • Allows filtering of outdoor air • Cost-effective in climates with extreme winters or summers and high fuel costs.	• Can cost more to install than other ventilation systems • May not be cost-effective in mild climates • May be difficult to find contractors with experience and expertise to install these systems • Require freeze and frost protection in cold climates • Require more maintenance than other ventilation systems.

Table 1: Pros and Cons of Various Mechanical Ventilation Systems[3]

Indoor air quality and ventilation needs vary greatly from home-to-home and the following factors should be considered:

* **Occupancy:** A house or apartment with one occupant has different ventilation needs than a household of five or more
* **Occupant susceptibility:** Some people are more susceptible than others to contaminants. Pollutant levels that cause an asthma attack in one person may cause no problems for someone else
* **Building characteristics:** The size, shape, design, and materials used in a building affect air leakage rates and pollutant sources
* **Pollutant load:** Each house and apartment have different sources and levels of indoor pollutants
* **Weather:** Temperature, wind, and humidity vary throughout the year in any single location and in different climate zones. Each of these weather factors affects indoor air quality[4]

Notes:

* *Mechanically providing fresh air to the space is in reality an energy penalty. We pay to heat and cool the raw air brought into the home and can, if not done properly, increase relative humidity within the living space. These systems require careful design and commissioning to ensure proper function and prevent over-ventilation.*

[3] https://www.energy.gov/energysaver/weatherize/ventilation/whole-house-ventilation
[4] https://homes.lbl.gov/ventilate-right/ventilation-and-health

*   *Best Practices:*
    1. *Design for positive pressure or balanced in our climate zone*
    2. *Do not suck on buildings in our climate zone (negative pressure/exhaust systems)*
        - [***BSI-069: Unintended Consequences Suck***]

Mechanical Whole-house Ventilation Visual:

Image 1: Exhaust Ventilation Strategy – requires controls to ensure run times are met.

Image 2: Common Supply Ventilation Systems – duct run from exterior to return plenum, automated mechanical damper and controls

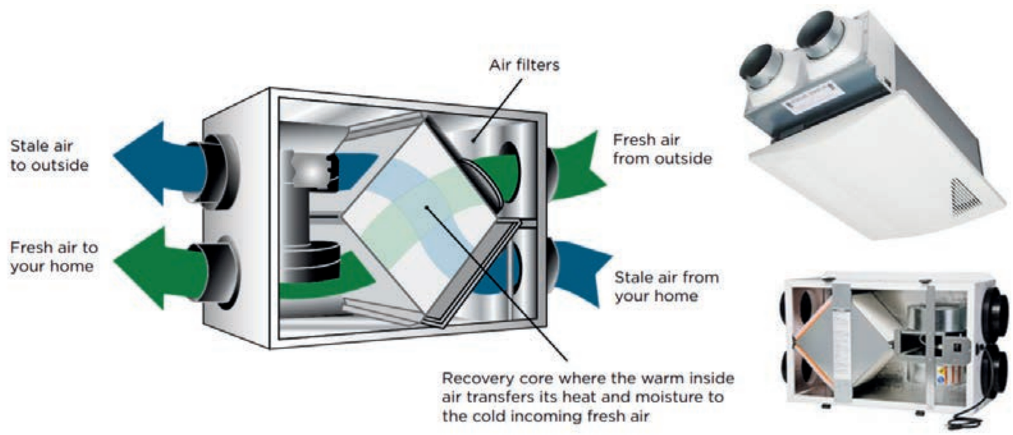


Image 1: Balanced Ventilation Strategy utilizing heat or enthalpy recovery

Whole-House Ventilation Code Reference:

Section M1507.1 Mechanical Ventilation. General. Where local exhaust or whole-house mechanical ventilation is provided, the equipment shall be designed in accordance with this section.

Section M1507.3 Whole-house mechanical ventilation system. Whole-house mechanical ventilation systems shall be designed in accordance with Sections M1507.3.1 through M1507.3.3

M1507.3.1 System Design. The whole-house ventilation system shall consist of one or more supply or exhaust fans, or a combination of such, and associated ducts and controls. Local exhaust or supply fans are permitted to serve as such a system. Outdoor air ducts connected to the return side of an air handler shall be considered as providing supply ventilation.

M1507.3.2 System Controls. The whole-house mechanical system shall be provided with controls that enable manual override.

M1507.3.3 Mechanical ventilation rate**.** The whole-house mechanical ventilation system shall provide outdoor air at a continuous rate of not less than that determined in accordance with Table M1507.3.3(1).

Exception: 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 M1507.3.3(1) is multiplied by the factor determined in accordance with Table M1507.3.3(2)

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

Table 1507.3.3(1) Continuous whole-house ventilation system airflow rate requirements

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.

Table 1507.3.3(2) Intermittent whole-house mechanical ventilation rate factors.

Section R403.6.1 Whole-house mechanical ventilation system fan efficacy. When installed to function as a whole-house mechanical ventilation system, fans shall meet the efficacy requirements of Table R403.6.1

> ***Exception:*** Where whole-house mechanical ventilation fans are integral to tested and listed HVAC equipment, they shall be powered by an electronically commutated motor.

FAN LOCATION	AIR FLOW RATE MINIMUM (CFM)	MINIMUM EFFICACY[a] (CFM/WATT)	AIR FLOW RATE MAXIMUM (CFM)
Range hoods	Any	2.8 cfm/watt	Any
In-line fan	Any	2.8 cfm/watt	Any
Bathroom, utility room	10	1.4 cfm/watt	< 90
Bathroom, utility room	90	2.8 cfm/watt	Any

Table R403.6.1 Whole-house mechanical ventilation system fan efficacy

Fresh Air Inlet Location Requirements Code Reference:

Section R303.5 Opening location. Outdoor intake and exhaust openings shall be located in accordance with sections R303.5.1 and R303.5.2.

R303.5.1 Intake openings. Mechanical and gravity outdoor air intake openings shall be located not less than 10 feet from any hazardous or noxious contaminant, such as vents, chimneys, plumbing vents, streets, alleys, parking lots and loading docks.

For the purpose of this section, the exhaust from dwelling unit toilet rooms, bathrooms and kitchens shall not be considered as hazardous or noxious.

Exceptions:

1. The 10-foot separation is not required where the intake opening is located 3 feet or greater below the contaminant source.
2. Vents and chimneys serving fuel-burning appliances shall be terminated in accordance with the applicable provisions of Chapters 18 and 24.
3. Clothes dryer exhaust ducts shall be terminated in accordance with Section M1502.3

Section R303.5.2 Exhaust openings. Exhaust air shall not be directed onto walkways.

R303.6 Outside opening protections**.** Air exhaust and intake openings that terminate outdoors shall be protected with corrosion-resistant screens, louvers or grilles having an opening size of not less than ¼ inch and a maximum opening size of ½ inch, in any dimension. Openings shall be protected against local weather conditions. Outdoor air exhaust and intake openings shall meet the provision for exterior wall opening protectives in accordance with this code.

Definitions:

Building Thermal Envelope: The basement walls, exterior walls, floor, roof and any other building elements that enclose conditioned space or provide a boundary between conditioned space and exempt or unconditioned space

Conditioned Space: An area, room or space that is enclosed within the building thermal envelope and that is directly heated or cooled or indirectly heated or cooled

Above-Grade Wall: A wall more than 50% 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 mansard roof and skylight shafts

Air Barrier: Material(s) assembled and joined together to provide a barrier to air leakage through the building envelope. An air barrier may be a single material or a combination of materials

R-Value: Resistance to Heat Flow of a single material, expressed as a whole number. Higher numbers denote higher resistance to heat flow

U-Value: Resistance to heat flow of multiple materials expressed as a decimal point. Lower numbers denote higher resistance to heat flow

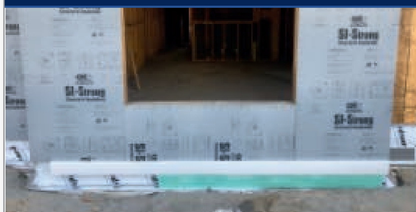
Infiltration: The uncontrolled inward air leakage into a building caused by the pressure effects of wind, or the effect of differences in the indoor and outdoor air density or both

slab edge

slab edge

Slab Edge Insulation

2015 IECC (w/ VA Specific Amendments) Plan Review Guide



Slab Edge Insulation:

Summary: Though the requirements have remained the same in the International Energy Conservation Code (IECC) and International Residential Code (IRC) since 2009, questions about placement of insulation, depth of insulation, the thermal break between conditioned and unconditioned spaces, and how additions or retrofits to existing homes should be handled remain.

Why: Slabs lose energy primarily as a result of heat conducted outward and through the perimeter of the slab. Installing insulation around the perimeter of the slab edge properly will prevent excessive heat loss and gain though the exposed concrete. *Insulation is included in slab-on-grade construction for two purposes:*

1. *Insulation prevents heat loss in winter, and heat gain in summer. This effect is most pronounced at the slab perimeter, where the slab edge often comes in direct contact with outdoor air/ambient conditions as it is placed above grade.*
2. *Even in climates and locations on the slab (perimeter vs. middle) where slab insulation may not confer large energy benefits, thermal isolation of the slab can prevent cool slab temperatures that can otherwise cause condensation inside the house. This can lead to mold and other moisture-related problems, especially if the slab is carpeted.*[1]

Items of Note:

* *Typical products used below grade: extruded polystyrene, expanded polystyrene, and rigid mineral fiber panels. (Baechler et al. 2005). Extruded polystyrene (XPS) is nominally R-5 per inch. Expanded polystyrene (EPS) nominally R-4 per inch and can be less expensive. Below-grade foams can be at risk for moisture accumulation under certain conditions.*[2]
    1. *All of the products listed would require 2+ Inches of insulation to achieve R-10.*
    2. *Depth of insulation in relation to wall assemblies can be of concern. Code allows the insulation to be cut away from the wall at a 45 degree angle for this reason.*
* *XPS has a higher initial insulating R-value than does a similar thickness and density of EPS, but the R-value of XPS degrades over time. EPS does not experience as much "thermal drift," and the reported R-value remains the same throughout its lifespan. EPS also has better drying*

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[1] https://foundationhandbook.ornl.gov/handbook/section4-1.shtml
[2] https://foundationhandbook.ornl.gov/handbook/section4-1.shtml

capabilities than XPS allowing it to perform better below grade in locations that can remain wet for large parts of the year.

* *For durability and insulation efficacy, final grade must be sloped away from the building. Long-term moisture degrades insulating value of slab insulations. Proper compressive strength and ground contact rated insulations should be specified.*

Visual Reference:

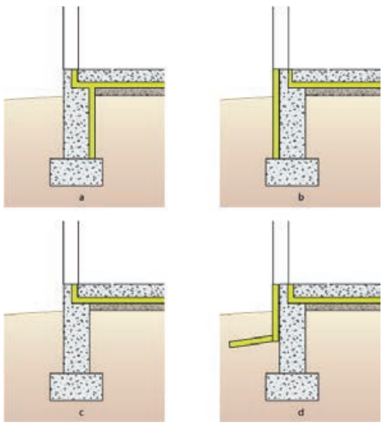

Figure 1: Common slab edge insulation locations[3]

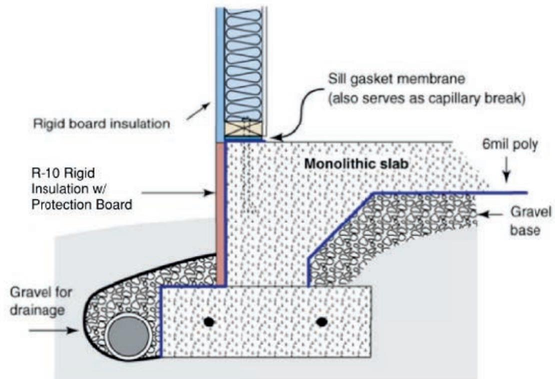

Figure 2: Example of monolithic pour with slab edge insulation

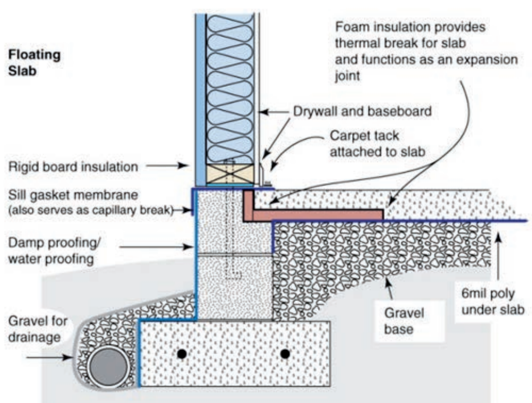

Figure 3: Slab and stem wall configuration

[3] https://foundationhandbook.ornl.gov/handbook/chapter4.shtml

Figure 4: Stem Wall insulated to height of Slab. Insulation to be cut at 45 degree angle away from wall (Code Section **R402.2.10)**

Figure 5: Slab Edge insulation with flashing and protection.

Plan Review Focus:

Construction Documentation: Review the construction documents for the details describing slab insulation installation and construction techniques

Vapor Barrier and Under-slab Fill: Ensure vapor barrier specified with all seams overlapped and taped. 57 Stone under slabs is recommended as a moisture control strategy but not required by code

R-Value/Depth: Ensure R-Value is denoted in drawings and current details achieve a full thermal break at the slab edge from the top of the slab to 2’ below grade. Ensure Thermal Envelope is completed leaving no gaps between Wall and slab edge insulation coverage

Insulation Protection: Confirm that the construction documents specify proper insulation protection if applicable. Rigid foam board is typically used for insulating slabs

Flashing: Confirm that the construction documents specify the proper location for installing flashing and flashing material

2015 IECC/IRC Code Reference:

Table R402.1.2/N1102.1.2

Climate Zone	4 except Marine	5 and Marine 4
Slab R-Value	R-10	R-10
Depth	2 ft	2 ft

Insulation to R-5 should be added to the required slab edge R-values for heated slabs. For heated slabs in Climate Zones 1 through 3, install the insulation to the depth of the footing or to 2 feet, whichever is less. A heated slab is a type of construction that has a slab-on-grade concrete floor with a heating system embedded in or beneath the slab floor. Building additions that include a slab-on-grade construction also are subject to the slab edge requirements listed in the IECC/IRC.

Section R103.2/N1101.5 Information on Construction Documents. 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...Details shall include but are not limited to, as applicable:

1. Insulation materials and R-Values. (*Items 2-8 not shown, see Chapter 11 of Virginia Residential Code)

Section R303.1.1/N1101.10.1 Building thermal envelope insulation. An R-value identification mark shall be applied by the manufacturer to each piece of building thermal envelope insulation 12" or greater in width. Alternately, the insulation installers shall provide a certification listing the type, manufacturer and R-Value of insulation installed in each element of the building thermal envelope. For blown or sprayed insulation (fiberglass and cellulose), the initial installed thickness, settled thickness, settled R-Value, installed density, coverage area and number of bags installed shall be listed on the certification.

***Section R402.2.10/N1102.2.10 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 R402.1.2/N1102.1.2. **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 to the distance provided in Table R402.1.2/N1102.1.2 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 a a 45 degree angle away from the exterior wall. Slab-edge insulation is not required in jurisdictions designated by the buidling officisal as having a very heavy termite infestation.

Section R303.2.1/N1101.11.1 Protection of exposed foundation insulation. Insulation applied to the exterior of basement walls, crawlspace walls and the perimeter of slab-on-grade floors shall have a rigid, opaque and weather-resistant protective covering to prevent degradation of the insulation's thermal performance. The protective covering shall cover the exposed exterior insulation and extend not less than 6 inches below grade.

Section R703.4 Flashing. Approved corrosion resistant flashing should be applied in shingle fashion to prevent entry of water into the wall cavity or penetration of water to the building structural framing components.

Section R703.8.5 Flashing. Flashing should be located beneath the first course of masonry above the finished ground level, **above the foundation wall or slab**, and at other points of support including structural floors.

Definitions:

Slab-on-Grade: Slab floor less than 12" below grade requiring insulation

Vapor Retarder: A material or product that controls the migration of moisture due to vapor diffusion

Heated Slab: Slab-on-grade construction in which the heating elements, hydronic tubing, or hot air distribution system is in contact with, or placed within or under, the slab

Infiltration: The uncontrolled inward air leakage into a building caused by the pressure effects of wind, or the effect of differences in the indoor and outdoor air density or both

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thank you to the participating jurisdictions

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CITY OF HAMPTON	JAMES CITY COUNTY
CITY OF NORFOLK	MONTGOMERY COUNTY
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