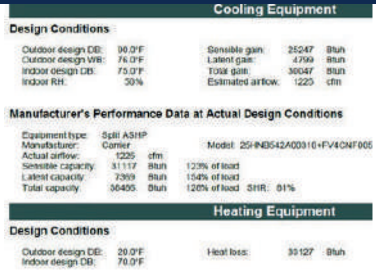
Heating/Cooling Design, Equipment, and Installation

2021 VRC/VECC Code Guide



Cooling Equipment

Design Conditions

Outdoor design DB:	90.0°F	Sensible gain:	25247 Btuh
Outdoor design WB:	76.0°F	Latent gain:	4799 Btuh
Indoor design DB:	75.0°F	Total gain:	30047 Btuh
Indoor RH:	50%	Estimated airflow:	1225 cfm

Manufacturer's Performance Data at Actual Design Conditions

Equipment type:	Split ASHP		
Manufacturer:	Carrier		Model: 25HNB542A00310+FV4CNF005
Actual airflow:	1225 cfm		
Sensible capacity:	31117 Btuh	123% of load	
Latent capacity:	7369 Btuh	154% of load	
Total capacity:	38485 Btuh	128% of load	SHR: 81%

Heating Equipment

Design Conditions

Outdoor design DB:	20.0°F	Heat loss:	30127 Btuh
Indoor design DB:	70.0°F		

Resources for code-compliant heating and cooling design and installation:

For residential heating/cooling, the Air Conditioning Contractors of America Association, Inc. – commonly known as ACCA – publishes Manual J, Manual S, and Manual D, which contain protocols and formulas to guide load calculation, equipment selection, and duct design respectively. Virginia Residential Code has required the use of all three of these manuals – or approved substitutes – since the 2009 edition.

The following pages provide a variety of resources for designers, installers, and code officials to help ensure that calculations associated with a particular home are accurate and complete – and that the ensuing installation is completed in compliance with code requirements.

- Brochures on Manual J, S, and D from ACCA, the Air Conditioning Contractors of America
- "Understanding and Using the HVAC Design Review Form" and a sample HVAC Design Review Form – both from ACCA
- Viridiant's "Understanding Select Fields on the Residential Plans Examiner Review Form for HVAC System Design"
- Viridiant's "TECH TIPS: HVAC Installation"

Additional Resources:

- https://www.acca.org/viewdocument/hvac-brochures-for-code-officials
- https://www.acca.org/viewdocument/residential-system-design-review-forms-examples
- https://www.acca.org/viewdocument/hvac-quality-installation-specification-english-1

2021 VRC/VECC Code References:

N1103.7 (R403.7) (M1401.3) Equipment and appliance sizing. Heating and cooling equipment and appliances shall be sized in accordance with ACCA Manual S or other approved sizing methodologies based on building loads calculated in accordance with ACCA Manual J or other approved heating and cooling calculation methodologies.

Exception: Heating and cooling equipment and appliance sizing shall not be limited to the capacities determined in accordance with Manual S or other approved sizing methodologies where any of the following conditions apply:

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

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

M1411.6.1 Refrigerant line insulation protection. Refrigerant piping insulation shall be protected in accordance with Section N1103.4.1.

N1103.4 (R403.4) Mechanical system piping insulation. Mechanical system piping capable of carrying fluids greater than 105°F (41°C) or less than 55°F (13°C) shall be insulated to an R-value of not less than R-3.

N1103.4.1 (R403.4.1) Protection of piping insulation. Piping insulation exposed to weather shall be protected from damage, including that caused by sunlight, moisture, equipment maintenance and wind. The protection shall provide shielding from solar radiation that can cause degradation of the material. Adhesive tape shall be prohibited.

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

M1601.6 Independent garage HVAC systems. Furnaces and air-handling systems that supply air to living spaces shall not supply air to or return air from a garage.

M1602.1 Outdoor air openings. Outdoor intake openings shall be located in accordance with Section R303.5.1. Opening protection shall be in accordance with Section R303.6

M1602.2 Return air openings. Return air openings for heating, ventilation and air-conditioning systems shall comply with all of the following:

1. Openings shall not be located less than 10 feet (3048 mm) measured in any direction from an open combustion chamber or draft hood of another appliance located in the same room or space.
2. The amount of return air taken from any room or space shall be not greater than the flow rate of supply air delivered to such room or space.
3. Return and transfer openings shall be sized in accordance with the appliance or equipment manufacturer's installation instructions, Manual D or the design of the registered design professional.
4. Return air shall not be taken from a closet, bathroom, toilet room, kitchen, garage, mechanical room, boiler room, furnace room or unconditioned attic.

   Exceptions:
   1. Taking return air from a kitchen is not prohibited where such return air openings serve the kitchen only, and are located not less than 10 feet (3048 mm) from the cooking appliances.
   2. Dedicated forced-air systems serving only the garage shall not be prohibited from obtaining return air from the garage.

5. For other than dedicated HVAC systems, return air shall not be taken from indoor swimming pool enclosures and associated deck areas except where the air in such spaces is dehumidified.
6. Taking return air from an unconditioned crawl space shall not be accomplished through a direct connection to the return side of a forced-air furnace. Transfer openings in the crawl space enclosure shall not be prohibited.
7. Return air from one dwelling unit shall not be discharged into another dwelling unit. **Exception**: The return air within a two-family dwelling constructed without fire separations in accordance with Exception 3 of Section R302.3 shall be permitted to discharge into either dwelling unit.

Definitions:

CLIMATE ZONE. A geographical region based on climatic criteria as specified in this code.

CONDITIONED FLOOR AREA. The horizontal projection of the floors associated with the conditioned space.

CONDITIONED SPACE. An area, room or space that is enclosed within the building thermal envelope and that is directly or indirectly heated or cooled. Spaces are indirectly heated or cooled where they communicate through openings with conditioned spaces, where they are separated from conditioned spaces by uninsulated walls, floors or ceilings, or where they contain uninsulated ducts, piping or other sources of heating or cooling.

DUCT. A tube or conduit utilized for conveying air. The air passages of self-contained systems are not to be construed as air ducts.

DUCT SYSTEM. A continuous passageway for the transmission of air that, in addition to ducts, includes duct fittings, dampers, plenums, fans and accessory air-handling equipment and appliances.

THERMAL DISTRIBUTION EFFICIENCY (TDE). The resistance to changes in air heat as air is conveyed through a distance of air duct. TDE is a heat loss calculation evaluating the difference in the heat of the air between the air duct inlet and outlet caused by differences in temperatures between the air in the duct and the duct material. TDE is expressed as a percent difference between the inlet and outlet heat in the duct.

THERMAL ISOLATION. Physical and space conditioning separation from conditioned spaces. The conditioned spaces shall be controlled as separate zones for heating and cooling or conditioned by separate equipment.

THERMOSTAT. An automatic control device used to maintain temperature at a fixed or adjustable setpoint.

VENTILATION. The natural or mechanical process of supplying conditioned or unconditioned air to, or removing such air from, any space.

VENTILATION AIR. That portion of supply air that comes from outside (outdoors) plus any recirculated air that has been treated to maintain the desired quality of air within a designated space.

ACCA®

Air Conditioning Contractors of America

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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
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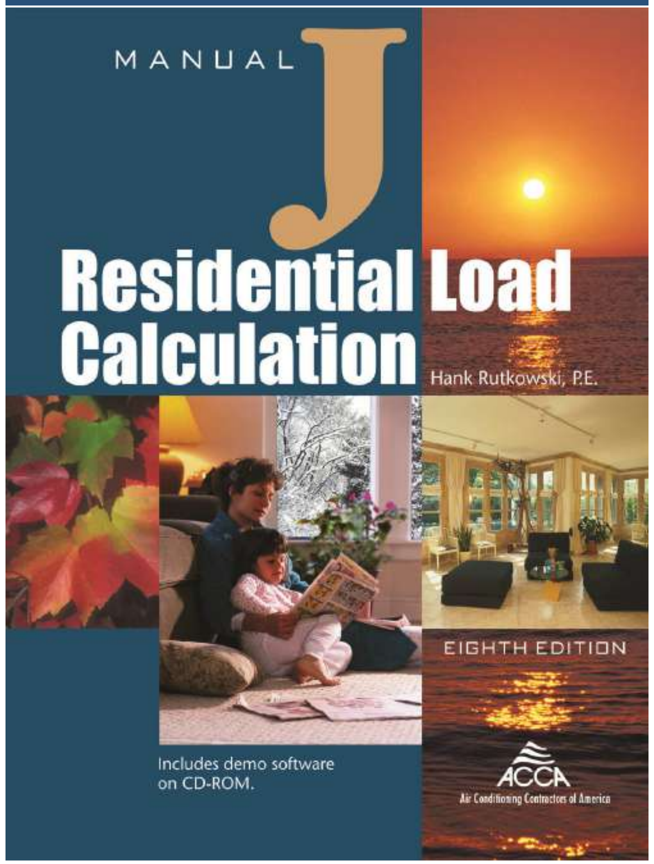
Verifying ACCA Manual J® Procedures



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 <u>excluded</u> from the infiltration calculations?	YES	NO	N/A
		✓ Continuous Exhaust Fans	Are dedicated exhaust fans (continuous) <u>included</u> 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 calculation.

Sponsored by the ACCA
Codes Committee

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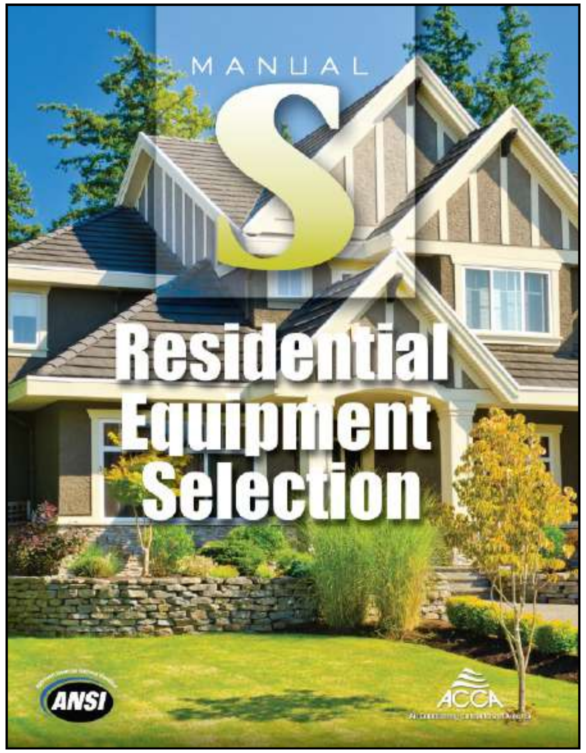
For a more detailed analysis on the design process
visit www.acca.org for
Bob's House

To order ACCA Manual S
888-290-2220

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.

ACCA'S Residential Design Manuals

System Process

Load Calculation	ACCA Manual J
Equipment Selection	**ACCA Manual S**
Duct Design	ACCA Manual D
Air Distribution	ACCA Manual T
Test, Adjust, and Balance	ACCA Manual B

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	Furnace Model Number:	FU600300	Fictitious furnace
Indoor °F:	70°F	Manual J8 §3-6 defaults to 70°F			
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%)
			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.)
			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

$$SHR = \frac{\text{Sensible Heat}}{\text{Total Heat Gain}} \quad C \qquad .85 = \frac{23{,}321\text{Btu/h}}{27{,}543\text{Btu/h}}$$

Sensible Heat Ratio versus Temperature Design Value

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

D

85% ≈ 19° Design Temp

$$CFM = \frac{\text{Sensible Heat Gain}}{\text{Design Temp x 1.1}}$$

$$1{,}116\ CFM = \frac{23{,}321\ \text{Btu/h}}{19 \times 1.1}$$

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

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

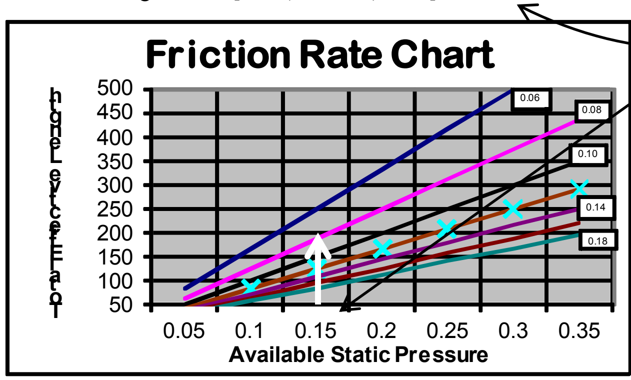
Step 3) Available Static Pressure (ASP)

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



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		
Kitchen	125	2 – 6"	2 - 10x4, 625fpm	ACCA does not recommend installing return ducts in kitchens, baths, laundry, or utility rooms	
Bath 1	65	1 – 6"	1 - 10x4, 600fpm		
Bath 2	40	1 – 5"	1 - 8x4, 500fpm		
Bath 3					
TOTALS	1200				

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

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

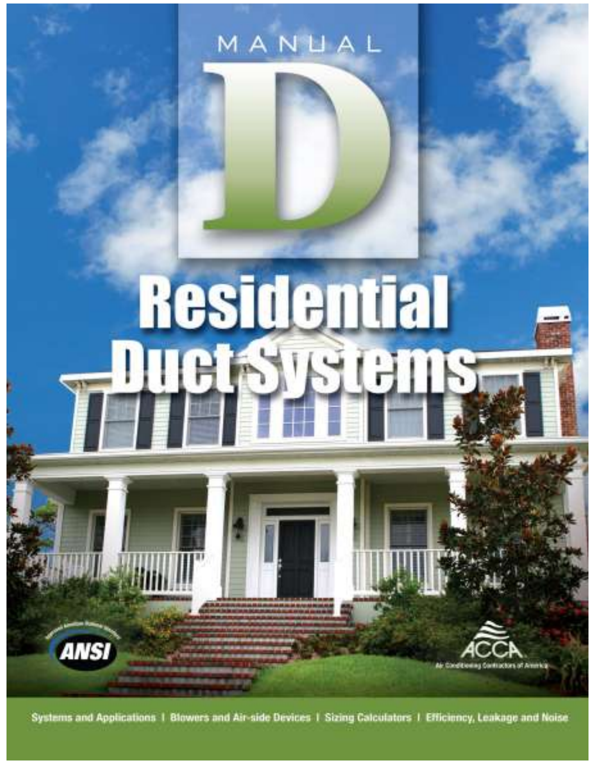
visit www.acca.org for

Bob's House

To order ACCA Manual D

888-290-2220

Verifying ACCA Manual D®



Includes Duct Inspection Checklist

ACCA
AIR CONDITIONING CONTRACTORS OF AMERICA®

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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

Understanding and Using the HVAC Design review Form

Each of the 32 points of requested information is discussed, and references to the supporting manual are given to substantiate the requirement.

Table of Contents

County, Town, Municipality, Jurisdiction - Header Information

Contractor ____________________

Mechanical License # ____________________

Building Plan # ____________________

Applicable Attachments

Manual J1 Form and Worksheet A:	Yes ☐	No ☐
OEM performance data (heating, cooling, blower):	Yes ☐	No ☐
Duct distribution sketch	Yes ☐	No ☐
IRC Table R301.2 (climatic & geographic design criteria)	Yes ☐	No ☐

Home Address (Street or Lot #, Block, Subdivision) ____________________

HVAC LOAD CALCULATION (IRC M1401.3)

Manual J Design Criteria and Loads

Location 1
Elevation ______ft
Altitude Correction Factor ______ ACF
Latitude ______° N

Winter Design Conditions 2
Outdoor Winter Temp ______°F
Indoor Winter Temp 3 ______°F
Heating Temp Diff ______°F

Summer Design Conditions
Outdoor Cooling Temp 5 ______°F
Indoor Cooling Temp 6 ______°F
Cooling Temp Diff ______°F
Indoor Summer Design RH ______%
Coincident Wet Bulb Temp ______°F

Manual J Loads
Total Heat Loss 4 ______Btu
Sensible Heat Gain 7 ______Btu
Latent Heat Gain 8 ______Btu
Total Heat Gain 9 ______Btu

10 **The heat loss / gain was calculated in accordance with ACCA Manual J?** ☐ Y ☐ N

HVAC EQUIPMENT SELECTION (IRC M1401.3)

Heating Equipment 11
☐ Furnace ☐ Boiler ☐ Aux. Heat w/Heat Pump
☐ Single Stage ☐ Multi-Stage ☐ Modulating

Model 12 ____________________
Output 13 ______ Btu Sizing Value ______ Btu
Aux. Heat 14 ______ Btu Size Limit ______ %
Load: Capacity ______ %

Cooling Equipment 15
☐ Air Conditioner ☐ Heat Pump
☐ Air-to-Air ☐ Geothermal Open ☐ Geothermal Closed
☐ Single Speed ☐ Multi-Stage ☐ Variable Speed

Model 16 ____________________
Sensible 17 ______ Btu Sizing Value ______ Btu
Latent 18 ______ Btu Size Limit ______ %
Total 19 ______ Btu Load: Capacity ______ %

20 **Size Factor is withing Manual S Size Limit?** ☐**Y** ☐**N**

21 **Size Factor is within Manual S Size Limit?** ☐**Y** ☐**N**

HVAC DUCT DISTRIBUTION DESIGN (IRC M1601.1)

Design Airflow 22 ______ Cfm
External Static Pressure (ESP) 23 ______ IWC
Component Pressure Loss (CPL) 24 ______ IWC
Available Static Pressure (ASP) 25 ______ IWC
ESP – CPL = ASP

Longest Supply Duct 26 ______ Ft
Longest Return Duct 27 ______ Ft
Total Effective Length (TEL) 28 ______ Ft
Friction Rate 29 ______ IWC
(ASP x 100) / TEL=Friction Rate

30 **Duct Materials Used:**
Trunk Duct: ☐ Duct Board ☐ Sheet metal ☐ Flex ☐ Lined Sheet metal ☐ Other
31 **Branch Duct:** ☐ Duct Board ☐ Sheet metal ☐ Flex ☐ Lined Sheet metal ☐ Other

Ducts are sized per Manual D? ☐**Y** ☐**N** 32

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

Contractor's Printed Name ____________________ Date __________

Contractor's Signature ____________________

UNDERSTANDING AND USING THE HVAC DESIGN REVIEW FORM

These instructions use standard forms and worksheets found in ACCA Manual J and ACCA Manual D. The Authority Having Jurisdiction (AHJ) shall have the discretion to accept information generated by software companies that are approved by ACCA. Such companies must demonstrate to ACCA that their software complies with the procedures in Manual J and Manual D. The current list of ACCA approved software vendors can be accessed by going to the link shown below:
Approved Software - ACCA

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. The ACCA Manual J1 Form accounts for all component loads applicable to the structure's physical construction details, or the plans for its final condition. If acceptable to the authority having jurisdiction (AHJ), an ACCA-approved software J1 report can be used in lieu of the ACCA J1 Form.
2. Record the location of the dwelling by selecting the nearest city or town that has climatic conditions as close to those locations listed in Table 1A or 1B from Manual J8 §A5-1. Record the elevation, latitude, and the altitude correction factor using Table 10A from Manual J or established criteria determined by the jurisdiction. See Figure 1 below as an example.

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	

3. Winter Outdoor Temp: Ensure this value comes from MJ8 Table 1A or 1B. Manual J8 §A5-1: "Use of this set of conditions is mandatory, unless a code or regulation specifies another set of conditions." See Figure 1 above, the Winter OD Temperature is -2°F. The same information can also be determined from Table 301.2, Climatic and Geographic Design Criteria, in the International Residential Code – (corrected 2024 edition), as shown below.

TABLE R301.2 CLIMATIC AND GEOGRAPHIC DESIGN CRITERIA

GROUND SNOW LOAD[o]	WIND DESIGN				SEISMIC DESIGN CATEGORY[f]	SUBJECT TO DAMAGE FROM			ICE BARRIER UNDERLAYMENT REQUIRED[h]	FLOOD HAZARDS[g]	AIR FREEZING INDEX[i]	MEAN ANNUAL TEMP[j]
	Speed[d] (mph)	Topographic effects[k]	Special wind region[l]	Windborne debris zone[m]		Weathering[a]	Frost line depth[b]	Termite[c]				
—	—	—	—	—	—	—	—	—	—	—	—	—
MANUAL J DESIGN CRITERIA[n]												
Elevation			Altitude correction factor[e]	Coincident wet bulb	Indoor winter design relative humidity	Indoor winter design dry-bulb temperature			Outdoor winter design dry-bulb temperature		Heating temperature difference	
—			—	—	—	—			—		—	
Latitude			Daily range	Summer design gains	Indoor summer design relative humidity	Indoor summer design dry-bulb temperature			Outdoor summer design dry-bulb temperature		Cooling temperature difference	
—			—	—	—	—			—		—	

4. 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."
5. 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.

6. Summer Outdoor Temp:
7. Summer Indoor temperature:
8. Sensible Heat Gain: This value represents the amount of dry heat the cooling system must remove.
9. Latent Heat Gain: This value represents the amount of moist heat the cooling system must remove.
10. Total Heat Gain: This value is used to size cooling systems; the total cooling capacity shall equal the sensible and latent heat gains.
11. Confirm whether the heat loss / heat gain was calculated in accordance with ACCA Manual J. See link above for approved software.

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.

Manual J load calculations should not be used to size equipment, only Manual S procedures or ACCA-approved Manual S software. In addition, AHRI certificates or AHRI performance data are not be used in lieu of Manual S OEM performance data and size tolerances.

Refer to the equipment sizing requirements (2021 IRC, Section M1401.3) from Manual S as shown below:

Overview of Size Limits for Residential HVAC Equipment

Equipment [a] ***Tested and Rated by the AHRI***	Attributes of Local Climate Notes b, c	Issue	Minimum (deficient) and Maximum(excessive) Capacity Factors. [d]					
		Cooling Capacity (Btuh)	Single-Speed Compressor			Multi- and Variable-Speed Compressor		
			Air-Air	GLHP [e]	GWHP [f]	Air-Air	GLHP [e]	GWHP [f]
Air-Air and Water-Air Cooling-Only & Heat Pump	Mild Winter or Has a Latent Cooling Load	Total	0.90 to 1.15		1.25	0.90 to 1.20_{multi} or $1.30_{variable}$		1.30_{m} or 1.35_{v}
		Latent	Minimum = 1.00. Preferred maximum = 1.50 (may exceed 1.5 if no reasonable alternative).					
		Sensible	Minimum = 0.90. Maximum determined by total and latent capacities.					
Air-Air and Water-Air Heat Pump Only	Cold Winter and No Latent Cooling load	Total	Maximum capacity = ***Manual J*** total cooling load plus 15,000 Btuh; Minimum factor = 0.90					
		Latent	Latent capacity for summer cooling is not an issue.					
		Sensible	Not an issue (determined by the limits for total cooling capacity).					

a) Central ducted; ductless single-split; ductless multi-split equipment. AHRI: Air Conditioning, Heating and Refrigeration Institute.
b) Mild winter: Heating degree days for base 65°F divided by cooling degree days for base 50°F less than 2.0. Cold winter = 2.0 or more.
c) Latent cooling load: ***Manual J*** sensible load divided by ***Manual J*** total load less than 0.95. No latent load = 0.95 or more.
d) Minimum and maximum capacity factors operate on the total, latent, and sensible capacity values produced by an accurate ***Manual J*** load calculation (per Section 2 of the Eighth Edition of ***Manual J***, version 2.0 or later). Multiply a size factor by 100 to convert to a percentage. For example, 1.15 excess capacity = 115% excess capacity.
e) GLHP: Ground loop heat pump (water in buried closed pipe loop).
f) GWHP: Ground water heat pump (ground water from well, pond, lake, river, etc., flows though equipment and is discarded).

Electric Heating Coils	Furnaces; Heat Pump supplement; emergency	Load (Btuh)	Maximum KW	Minimum Capacity Factor	Maximum Capacity Factor
		≤ 15,000	5.0	Satisfy Load	See Maximum KW
		> 15,000	See Min and Max	0.95	1.75

Minimum and maximum capacity factors operate on the heating load produced by an accurate ***Manual J*** load calculation. Multiply a size factor by 100 to convert to a percentage.

Natural Gas, Oil, Propane Furnaces	Duty	Minimum Output Capacity	Maximum Output Capacity
	Heating-only	1.00	1.40
	Heating-Cooling Preferred		
	Heating-Cooling Allowed		2.00

Minimum and maximum capacity factors operate on the heating load produced by an accurate ***Manual J*** load calculation. Multiply a size factor by 100 to convert to a percentage. For heating-cooling duty, blower performance must be compatible with the cooling equipment.

Electric, and	Duty	Minimum Output Capacity	Maximum Output Capacity

<table>
<tr><td>Fossil Fuel Water Boilers</td><td colspan="2">Gravity or forced convection terminals in the space, water coil in duct or air-handler.</td><td>1.00</td><td colspan="2">1.40</td></tr>
<tr><td colspan="6">Minimum and maximum capacity factors operate on the heating load produced by an accurate Manual J load calculation. Multiply a size factor by 100 to convert to a percentage. Refer to OEM guidance when a boiler is used for potable water heat, or snow melting.</td></tr>
<tr><td rowspan="3">Hot Water Coils</td><td colspan="2">Duty</td><td>Minimum Factor</td><td colspan="2">Maximum Factor</td></tr>
<tr><td colspan="2">Gravity or forced convection terminals in the space.</td><td rowspan="2">1.00</td><td rowspan="2">Two-position
1.25</td><td rowspan="2">Throttling
1.50</td></tr>
<tr><td colspan="2">Water coil in duct or air-handler.</td></tr>
<tr><td colspan="6">Minimum and maximum capacity factors operate on the heating load produced by an accurate Manual J load calculation. Multiply a size factor by 100 to convert to a percentage. Two-position= open-close valve; Throttling = Full modulating 2-way or 3-way valve.</td></tr>
<tr><td colspan="2">Electric and Fossil Fuel Water Heaters</td><td colspan="4">The space heating load is the Manual J load. The total load is the space heating load plus the potable water load. Refer to OEM guidance for selection and sizing guidance.</td></tr>
<tr><td colspan="2">Dual Fuel Systems</td><td colspan="4">Heat pump sizing rules apply, heating equipment sizing rules apply, see Section N2-11.</td></tr>
<tr><td colspan="2">Ancillary Dehumidification</td><td colspan="4">See Section N2-12. May allow +15,000 Btuh excess cooling capacity for cold winter climate.</td></tr>
<tr><td colspan="2">Humidifiers (Section N2-13)</td><td colspan="4">Minimum capacity } humidification load, excess capacity dependent on smallest size available.</td></tr>
<tr><td colspan="2">AHAM Cooling and Heat Pump Equipment</td><td colspan="4">See Section N2-14 for sizing rules.</td></tr>
<tr><td colspan="2">Direct Evaporative Cooling Equipment</td><td colspan="4">See Section N2-15 for sizing rules.</td></tr>
</table>

Figure 1: Manual S Sizing Limitations

Heating Equipment Data

11. 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.

12. Model: The model of heater that will be installed.

13. 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." Also see Section N2.4 of Manual S for Multi-stage furnaces. To obtain a copy of the 2014 edition of Manual S click on the link shown below.
[Online Store - ACCA]

14. Auxiliary heating output capacity: The auxiliary heat source that supplements the heat pump. 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 and the heat pump's capacity. 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

15. Equipment Type: A description of the cooling equipment that will be installed: air conditioner, heat pump, etc.

16. Model: The model of cooling equipment that will be installed. In Figure 11, the model is an AC -030.

17. 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…"

18. 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.

19. Total cooling capacity: The amount of maximum cooling capacity available from the equipment shall not exceed 115% of the heat gain. 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."

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.

20. Is the load capacity within the size limit? (heating)

The heating load (heat loss) is determined by the Manual J heat loss calculation. Per ACCA Manual S, furnace size should stay within the specified limits of Table 2.4 below. For heat pumps with electric resistance heat, refer to Table 2.3 in Manual S as shown below.

Size Limits for Fossil Fuel Furnaces			
Output Capacity for Heating-Only	***Single Stage*** Sizing value to 1.4 x sizing value	***Multi Stage*** Sizing value to 1.4 x sizing value at full capacity	***Modulate Burner*** Sizing value to 1.4 x sizing value at full capacity
Preferred 3 Output Capacity for Heating and Cooling	Sizing value to 1.4 x sizing value	Sizing value to 1.4 x sizing value at full capacity	Sizing value to 1.4 x sizing value at full capacity
Maximum 4 Output Capacity for Heating and Cooling	Sizing value to 2.0 x sizing value	Sizing value to 2.0 x sizing value at full capacity	Sizing value to 2.0 x sizing value at full capacity
Zone Damper Systems	Zone damper systems should have as little excess capacity as possible when full capacity is compared to the ***Manual J*** block load for the space served.		

a) Applies to natural gas, propane, and oil furnaces.

b) Sizing value = MJ8 block load (heating Btuh) for the space served by the equipment.

c) The 2.0 limit applies when the sizing value is 25,000 Btuh or less, but a need to use this limit indicates that a furnace is incompatible with the application. Consider a furnace that has a staged or modulating burner. Consider a heat pump, or a heating coil in a cooling equipment cabinet or duct, or baseboard heat, or radiant heat.

d) The excess output capacity factor shall range from 1.0 to 1.4 when furnace blower performance is adequate for cooling.

e) The excess output capacity factor may be as high as 2.0 when a larger furnace is the only way to obtain the necessary blower power for cooling.

- This option is exercised after the practitioner has investigated the performance of commonly available products, and found that exceeding the 1.4 limit is necessary and defensible.
- Consider a furnace that has a staged or modulating burner.
- Other solutions may be more compatible with the application. Consider a heat pump, or a heating coil in a cooling equipment cabinet or duct, or baseboard heat, or radiant heat, for example.

f) Minimum capacity = Sizing value

Table N2-4

Size Limits for Electric Heating Coils			
Heat Pump Supplemental Heat A balance point diagram determines the maximum amount of electric coil heat required (sizing value) when refrigeration cycle heat is active and functioning properly.			
Sizing Value	***Max KW***	***Max Factor***	***Min Factor***
15,000 Btuh or less	5.0	na	na
More than 15,000 Btuh	na	1.75	0.95
Heat Pump Emergency Heat When refrigeration cycle heat is not available, the sizing value for emergency heat is 85 percent of the design heating load value, or use the sizing value for supplemental heat when the supplemental heat value is larger than the emergency heat value.			
Sizing Value	***Max KW***	***Max Factor***	***Min Factor***
15,000 Btuh or less	5.0	na	na
More than 15,000 Btuh	na	1.75	0.95
Sole Source of Heat g) ***Electric furnace*** h) ***Electric coil in air handler cabinet, duct plenum, or duct run*** The design value for the heating load determines the sizing value for electric coil heat.			
Sizing Value	***Max KW***	***Max Factor***	***Min Factor***
15,000 Btuh or less	5.0	na	na
More than 15,000 Btuh	na	1.75	0.95
Zone Damper Systems Zone damper systems shall have as little excess heating capacity as possible for any non-emergency operating condition. • Stage heat pump supplemental heat. • Stage electric coils that are the only source of heat.			
1) Maximum and minimum capacity factors are applied to the sizing value. 2) Electric coils that have a total capacity of 10 KW or more should be staged. Use 2-1/2 to 7-1/2 KW increments, depending on what is possible for the available coil circuiting options (5 KW steps are the desired goal). 3 When staging is available, the maximum number of active stages should be enough to satisfy the minimum heating requirement (95% of the sizing value). Keep additional stages off line.			

Table N2-3

21. Is the load capacity within the size limit? (cooling)

The total cooling load is determined by the ACCA Manual J heat gain calculation. The summer heat gain is made up of the sensible load (outdoor temperature vs indoor temperature) and the latent load (humidity). Cooling equipment capacity should not exceed the total load more than the values listed in ACCA Manual S (see Figure 6).

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. Shown below is an example of such a worksheet from Manual D. The following link contains a list of those who have ACCA approved software for Manual D. [Approved Software - ACCA]

Friction Rate Worksheet

Step 1) Manufacturer's Blower Data

External static pressure (ESP) = ______ IWC Cfm = __________

Step 2) Component Pressure Losses (CPL)

Direct expansion refrigerant coil	______
Electric resistance heating coil	______
Hot water coil	______
Heat exchanger	______
Low efficiency filter	______
High or mid-efficiency filter	______
Electronic filter	______
Other items that impede airflow	______
Supply outlet	______
Return grille	______
Balancing damper	______
Zone damper (full open)	______
Total component losses (CPL)	______ IWC

Step 3) Available Static Pressure (ASP)

ASP = (ESP – CPL) = (______ – _______) = _______ IWC

Step 4) Total Effective Length (TEL)

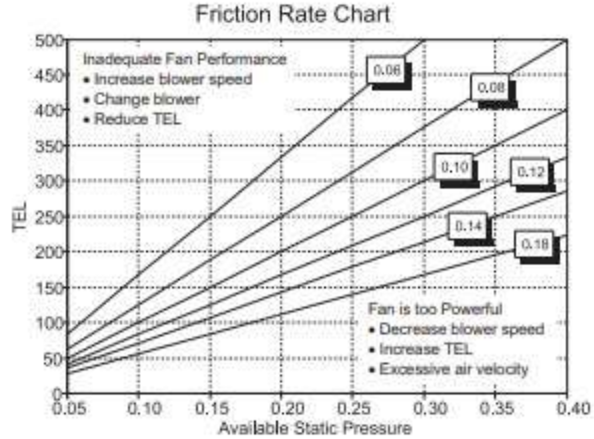
Supply-side TEL + Return-side TEL = (_______ + _______) = _______ Feet

Step 5) Friction Rate Design Value (FR)

FR value from friction rate chart = ______ IWC/100 Ft

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

Friction Rate Chart



22. 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 22. When selecting a blower assembly, the design airflow will be the higher of the two, 1,117 CFM.

23. 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[1] 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.

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

24. 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 23 the component pressure loss is 0.40.

25. Available Static Pressure (ASP): The difference between the external static pressure (item 31) and the component pressure losses (item 24). 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.

26. 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.

27. 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.

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

29. 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.

30. Duct Materials Used: For Trunk ducts 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.

31. Branch duct: See item 378.

32. Ducts are sized per Manual D?

See the above requirements from Manual D plus the duct distribution sketch and Figures 19 and 20.

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 ducted return. Ensure the duct calculator used has the appropriate scale for the duct material used.

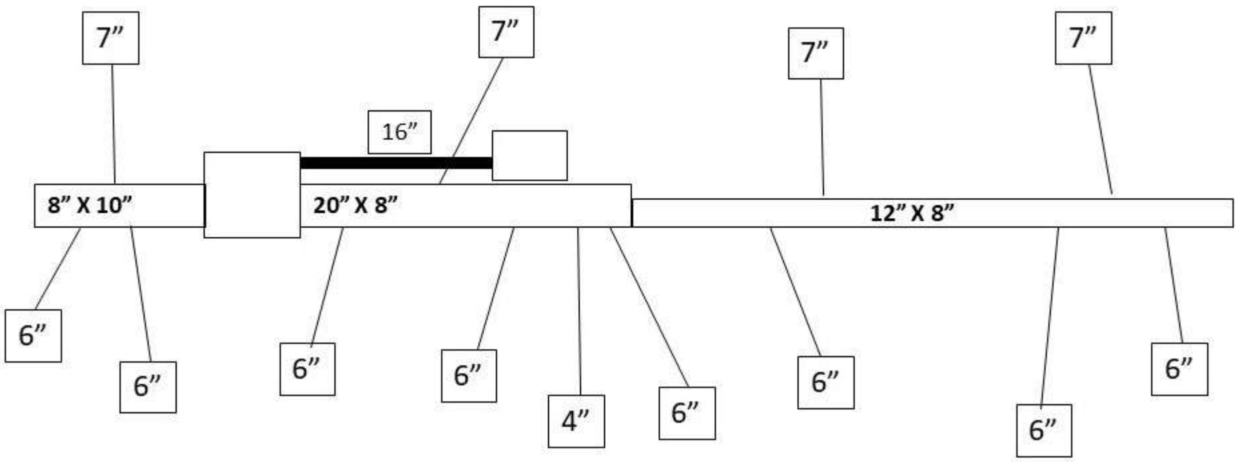


Figure 2: Example Duct Sketch

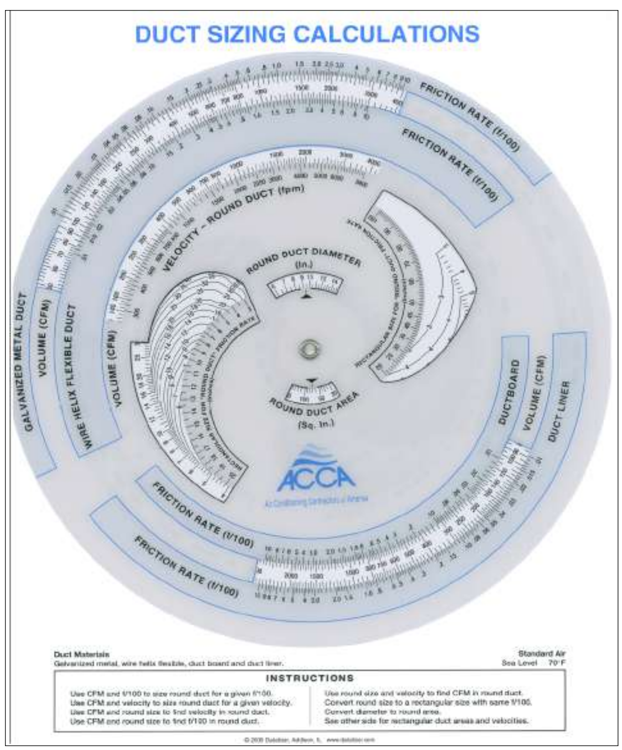


Figure 3: ACCA Duct Calculator

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

Form
RPER 2.0

Air Conditioning Contractors of America

County, Town, Municipality, Jurisdiction - Header Information

Contractor ________________________________

Mechanical License # ________________________

Building Plan # ____________________________

Applicable Attachments

Manual J1 Form and Worksheet A:	Yes ☐	No☐
OEM performance data (heating, cooling, blower):	Yes ☐	No☐
Duct distribution sketch	Yes ☐	No☐
IRC Table R301.2 (climatic & geographic design criteria)	Yes ☐	No☐

Home Address (Street or Lot #, Block, Subdivision) ____

HVAC LOAD CALCULATION (IRC M1401.3)

Manual J Design Criteria and Loads

Location

Elevation _______ft
Altitude Correction Factor _______ ACF
Latitude _______° N

Winter Design Conditions

Outdoor Winter Temp _______°F
Indoor Winter Temp _______°F
Heating Temp Diff _______°F

Summer Design Conditions

Outdoor Cooling Temp _______°F
Indoor Cooling Temp _______°F
Cooling Temp Diff _______°F
Indoor Summer Design RH _______%
Coincident Wet Bulb Temp _______°F

Manual J Loads

Total Heat Loss _______Btu

Sensible Heat Gain _______Btu
Latent Heat Gain _______Btu
Total Heat Gain _______Btu

The heat loss / gain was calculated in accordance with ACCA Manual J? ☐ Y ☐ N

HVAC EQUIPMENT SELECTION (IRC M1401.3)

Heating Equipment

☐ Furnace ☐ Boiler ☐ Electric Heat
☐ Single Stage ☐ Multi-Stage ☐ Modulating

Model ____________________

Output _______ Btu
Supplemental Heat _______ Btu
Sizing Value _______ Btu
Size Limit _______ %
Load: Capacity _______ %

Size Factor is within Manual S Size Limit? ☐ Y ☐ N

Cooling Equipment

☐ Air Conditioner ☐ Heat Pump
☐ Air-to-Air ☐ Geothermal Open Loop ☐ Geothermal Closed Loop
☐ Single Speed ☐ Multi-Stage ☐ Variable Speed

Model ____________________

Sensible _______ Btu
Latent _______ Btu
Total _______ Btu
Sizing Value _______ Btu
Size Limit _______ %
Load: Capacity _______ %

Size Factor is within Manual S Size Limit? ☐ Y ☐ N

HVAC DUCT DISTRIBUTION DESIGN (IRC M1601.1)

Design Airflow _______ Cfm
External Static Pressure (ESP) _______ IWC
Component Pressure Loss (CPL) _______ IWC
Available Static Pressure (ASP) _______ IWC
ESP – CPL = ASP _______

Longest Supply Duct _______ Ft
Longest Return Duct _______ Ft
Total Effective Length (TEL) _______ Ft
Friction Rate _______ IWC
(ASP x 100) / TEL = Friction Rate _______

Duct Materials Used

Trunk Duct: ☐ Duct Board ☐ Sheet metal
☐ Flex ☐ Lined Sheet metal ☐ Other
Branch Duct: ☐ Duct Board ☐ Sheet metal
☐ Flex ☐ Lined Sheet metal ☐ Other

Ducts are sized per Manual D? ☐ Y ☐ N

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

Contractor's Printed Name ________________________________ Date ____________

Contractor's Signature ________________________________

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

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SEEA
SOUTHEAST ENERGY EFFICIENCY ALLIANCE

Residential HVAC

Tips for Enforcing the 2021 Virginia Code

The ***Residential Plans Examiner Review Form for HVAC System Design*** is a standardized template provided by Air Conditioning Contractors of America (ACCA). It provides key information about the load calculations that were performed. An updated form was released in 2024.

This form can be generated and pre-populated from the common software programs that are used to perform HVAC load calculations in accordance with ACCA Manual J.

This guide will cover best practices for reviewing the information on this form for accuracy.

ACCA
Air Conditioning Contractors of America

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

Form
RPER 2.0

County, Town, Municipality, Jurisdiction - Header Information

Contractor ______________________

Mechanical License # ______________________

Building Plan # ______________________

Applicable Attachments
Manual J1 Form and Worksheet A: Yes ☐ No ☐
OEM performance data (heating, cooling, blower): Yes ☐ No ☐
Duct distribution sketch Yes ☐ No ☐
IRC Table R301.2 (climatic & geographic design criteria) Yes ☐ No ☐

Home Address (Street or Lot #, Block, Subdivision) ______________________

HVAC LOAD CALCULATION (IRC M1401.3)

Manual J Design Criteria and Loads

Location
Elevation ______ ft
Altitude Correction Factor ______ ACF
Latitude ______ ° N

Winter Design Conditions
Outdoor Winter Temp ______ °F
Indoor Winter Temp ______ °F
Heating Temp Diff ______ °F

Summer Design Conditions
Outdoor Cooling Temp ______ °F
Indoor Cooling Temp ______ °F
Cooling Temp Diff ______ °F
Indoor Summer Design RH ______ %
Coincident Wet Bulb Temp ______ °F

Manual J Loads
Total Heat Loss ______ Btu
Sensible Heat Gain ______ Btu
Latent Heat Gain ______ Btu
Total Heat Gain ______ Btu

The heat loss / gain was calculated in accordance with ACCA Manual J? ☐ Y ☐ N

HVAC EQUIPMENT SELECTION (IRC M1401.3)

Heating Equipment
☐ Furnace ☐ Boiler ☐ Electric Heat
☐ Single Stage ☐ Multi-Stage ☐ Modulating

Model ______________________

Output ______ Btu
Supplemental Heat ______ Btu
Sizing Value ______ Btu
Size Limit ______ %
Load: Capacity ______ %

Size Factor is within Manual S Size Limit? ☐ Y ☐ N

Cooling Equipment
☐ Air Conditioner ☐ Heat Pump
☐ Air-to-Air ☐ Geothermal Open Loop ☐ Geothermal Closed Loop
☐ Single Speed ☐ Multi-Stage ☐ Variable Speed

Model ______________________

Sensible ______ Btu
Latent ______ Btu
Total ______ Btu
Sizing Value ______ Btu
Size Limit ______ %
Load: Capacity ______ %

Size Factor is within Manual S Size Limit? ☐ Y ☐ N

HVAC DUCT DISTRIBUTION DESIGN (IRC M1601.1)

Design Airflow ______ Cfm
External Static Pressure (ESP) ______ IWC
Component Pressure Loss (CPL) ______ IWC
Available Static Pressure (ASP) ______ IWC
ESP – CPL = ASP ______

Longest Supply Duct ______ Ft
Longest Return Duct ______ Ft
Total Effective Length (TEL) ______ Ft
Friction Rate ______ IWC
(ASP x 100) / TEL = Friction Rate ______

Duct Materials Used
Trunk Duct: ☐ Duct Board ☐ Sheet metal
☐ Flex ☐ Lined Sheet metal ☐ Other
Branch Duct: ☐ Duct Board ☐ Sheet metal
☐ Flex ☐ Lined Sheet metal ☐ Other

Ducts are sized per Manual D? ☐ Y ☐ N

HVAC Load Calculation – Design Conditions

Tips for Enforcing the 2021 Virginia Code

Winter Design Conditions

Outdoor Winter Temp ______ °F
Indoor Winter Temp ______ °F
Heating Temp Diff ______ °F

Summer Design Conditions

Outdoor Cooling Temp ______ °F
Indoor Cooling Temp ______ °F
Cooling Temp Diff ______ °F
Indoor Summer Design RH ______ %
Coincident Wet Bulb Temp ______ °F

New in the 2018 Virginia Residential Code was the addition of the Manual J Design Criteria table to Table R301.2(1).

Each jurisdiction should provide the design criteria that all contractors should use in their Manual J calculations.

Reviewers can then verify that their jurisdiction's design criteria were used in the Manual J.

MANUAL J DESIGN CRITERIA[n]						
Elevation	Altitude correction factor[e]	Coincident wet bulb	Indoor winter design relative humidity	Indoor winter design dry-bulb temperature	Outdoor winter design dry-bulb temperature	Heating temperature difference
—	—	—	—	—	—	—
Latitude	Daily range	Summer design grains	Indoor summer design relative humidity	Indoor summer design dry-bulb temperature	Outdoor summer design dry-bulb temperature	Cooling temperature difference
—	—	—	—	—	—	—

HVAC Load Calculation – Design Conditions

Tips for Enforcing the 2021 Virginia Code

Manual J Loads

Total Heat Loss	________	Btu

Sensible Heat Gain	________	Btu
Latent Heat Gain	________	Btu
Total Heat Gain	________	Btu

Total Heat Loss describes the amount of heat that will be lost from the building during the coldest hours of the winter. This heat loss needs to be made up by a heating source. The combined capacity of the heating equipment and any supplemental heat sources should meet or exceed this value.

Cooling is described by **Sensible Gain** and **Latent Gain**, as well as **Total Heat Gain**, which is the sum of the Sensible and Latent loads. Sensible gain is the heat gained by the building in the summer. Latent gain is the moisture gain.

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

Success with the 2021 Virginia Energy Conservation Code

HVAC INSTALLATION

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VIRGINIA

TECH TIPS:
HVAC Installation

1. Seal all duct terminations to adjacent drywall and/or subfloor. Seal all HVAC penetrations in the building envelope with foam, caulk, or mastic. Use fire-rated sealants where required. (R402.4.1.1 Installation and elsewhere)

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TECH TIPS:
HVAC Installation

2. Seal all HVAC components at all joints, seams, and corners. (R403.3.4 Sealing)

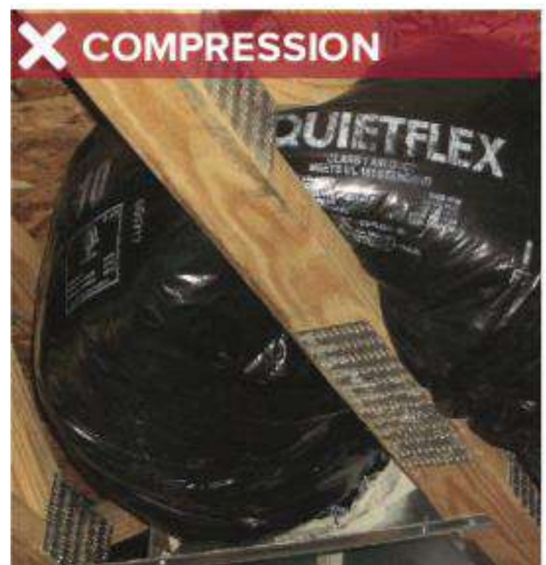
3. Mechanically fasten all metal duct work with screws. For flexible duct, attach the inner liner with plastic straps and tighten with a manufacturer-approved tool. (M1601.4 Installation)

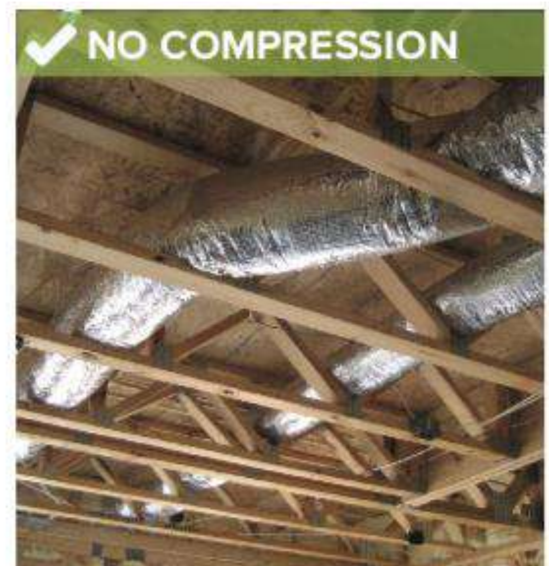
IECC Tech Tips
VIRGINIA

TECH TIPS:
HVAC Installation

4. Insulate all ducts outside of conditioned space to at least R-8 if duct is 3 inches or more in diameter; R-6 for ducts less than 3 inches in diameter. (R403.3.1 Insulation)

5. Do not compress insulated flexible ducts more than the thickness of the insulation. (Manufacturer's instructions)

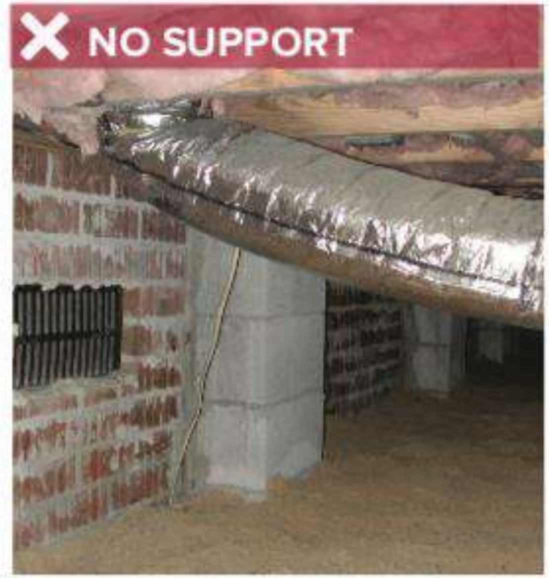


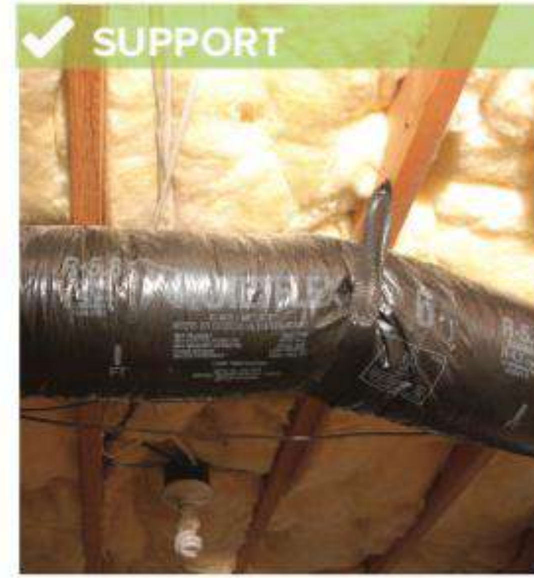


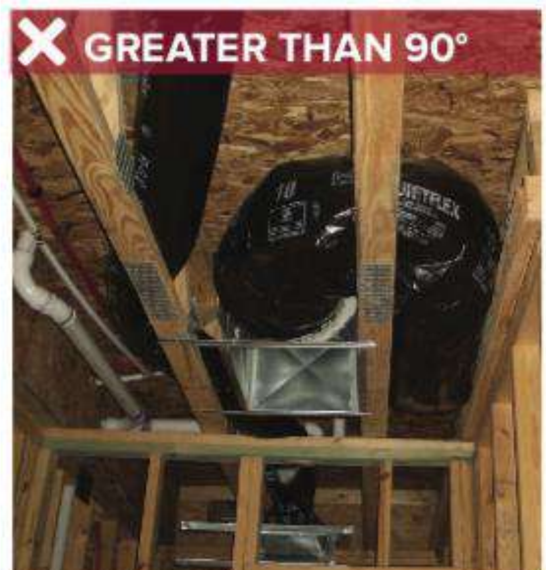
TECH TIPS:

HVAC Installation

6. Support flexible ducts (including those for ventilation) at least every 4 feet. Do not bend more than 90 degrees. (Manufacturer’s instructions)







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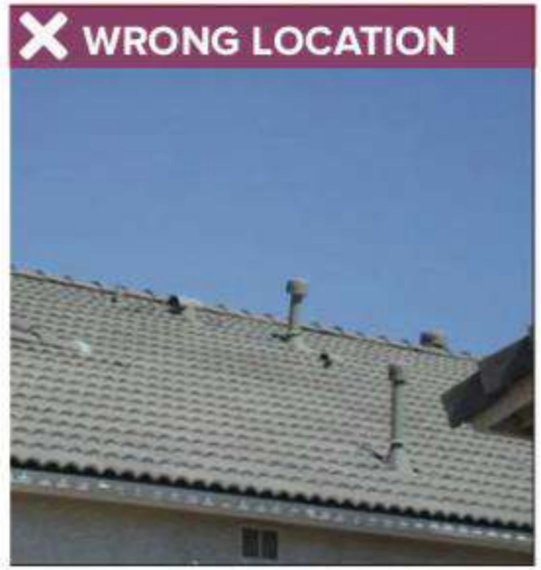
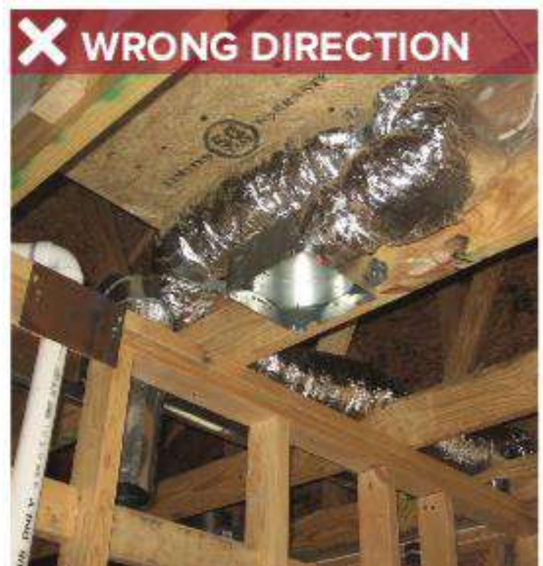
TECH TIPS:

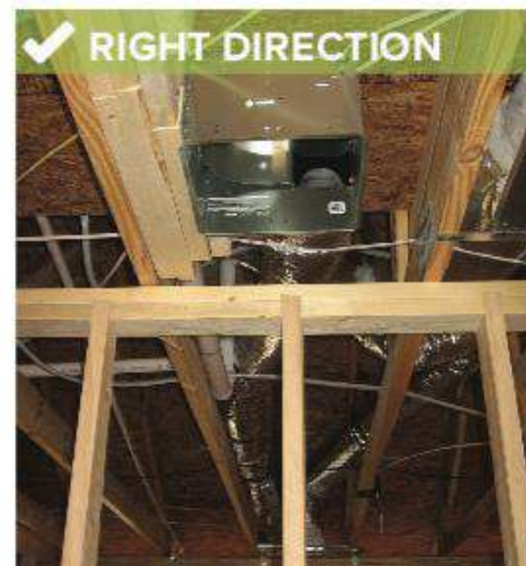
HVAC Installation

7. Install outside air ventilation intakes at least 10 feet from any exhaust vent or stack. (M1504.3 Exhaust openings)



8. Coordinate bath fan exhaust duct direction with electrical contractor (or other fan installer) to ensure ductwork is as short and straight as possible.

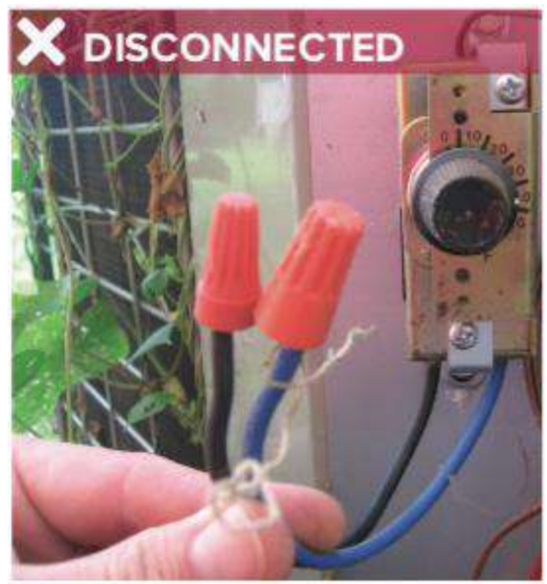




TECH TIPS:
HVAC Installation

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

10. For heat pumps, install a heat strip outdoor temperature lockout that prevents supplemental heat operation when the heat pump compressor can meet the heating load. Set it to an appropriate balance point based on local climate. (R403.1.2 Heat pump supplementary heat)



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TECH TIPS:
HVAC Installation

Best practices for air-tight ductwork: Mastic

All duct leakage penalizes comfort, efficiency, durability, and moisture management.

Virginia code first established a numerical limit to duct leakage with the 2009 edition and began requiring testing for heating/cooling ductwork outside of the building envelope with the 2015 edition. With the 2021 edition, the leakage limit is 4% if the ducts are outside of conditioned space, 8% if within.

Sealing ducts with bucket mastic and fabric mesh is widely considered the most reliable and durable method of minimizing duct leakage.

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TECH TIPS:

HVAC Installation

Best practices for air-tight ductwork: Mastic

TECH TIPS:

HVAC Installation

Best practices for air-tight ductwork: Mastic

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VIRGINIA

TECH TIPS:
HVAC Installation

Best practices for air-tight ductwork:
Mastic

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