UNDERSTANDING AND USING THE HVAC DESIGN REVIEW FORM

Each of the 38 points of requested information is discussed, and references to the supporting manual are given to substantiate the requirement.

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ACCA Air Conditioning Contractors of America

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

Form RPER 1.01 8 Mar 10

County, Town, Municipality, Jurisdiction
Header Information

Contractor: ABC Heating and Air Conditioning Company
Mechanical License #: MCL# 123456789
Building Plan #: Model P54321-987, dated 13 June 2010
Home Address (Street or Lot#, Block, Subdivision): 123 Elm Street, Beatrice, Nebraska

REQUIRED ATTACHMENTS[1]	ATTACHED
Manual J1 Form (and supporting worksheets):	Yes ☒ No ☐
or MJ1AE Form[2] (and supporting worksheets):	Yes ☐ No ☒
OEM performance data (heating, cooling, blower):	Yes ☒ No ☐
Manual D Friction Rate Worksheet:	Yes ☒ No ☐
Duct distribution system sketch:	Yes ☒ 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 Δ (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 CFM (27) 1,117 CFM
- Cooling CFM (28) 1,000 CFM

HVAC DUCT DISTRIBUTION SYSTEM DESIGN (IRC M1601.1)

- Design airflow (29) 1,117 CFM
- External Static Pressure (ESP) (30) 0.75 IWC
- Component Pressure Losses (CPL) (31) 0.40 IWC
- **Available Static Pressure (ASP)** (32) 0.35 IWC
  ASP = ESP - CPL
- Longest supply duct: (33) 278 Ft
- Longest return duct: (34) 110 Ft
- **Total Effective Length (TEL)** (35) 388 Ft
- **Friction Rate:** (36) 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-8) (37)
- Branch Duct: Duct board, Flex, Sheet metal, Lined sheet metal, Other (specify): Flex duct (insulated R-8) (38)

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 2010

Contractor's Signature:

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

[1] The AHJ shall have the discretion to accept Required Attachments printed from approved ACCA software vendors, see list on page 2 of instructions.
[2] If abridged version of Manual J is used for load calculation, then verify residence meets requirements, see Abridged Edition Checklist on page 13 of instructions.

SECTION I: HVAC LOAD CALCULATION:

These instructions use standard forms and worksheets found in Manual J and Manual D. The AHJ shall have the discretion to accept information generated by software companies that have demonstrated their software follows the procedures in ACCA design manuals. The current list of approved software vendors, listed alphabetically, is:

Manual J

Adtek (www.adteksoft.com)
Elite (www.elitesoft.com))
Florida Solar Energy Center (Florida only)
Nitek (www.hvaccomputer.com)
Wrightsoft (www.wrightsoft.com)

Manual D

Elite (www.elitesoft.com
Wrightsoft (www.wrightsoft.com)

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 the 55%, or 50%, or 45% value for this design element. Code Officials may wish to refer to IECC Figure 301.1 Climate Zones.
7. Orientation (e.g., North, South…): Verify that 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 and skylight should be listed as facing South. The cooling loads for windows and skylights are very dependent on direction.
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.

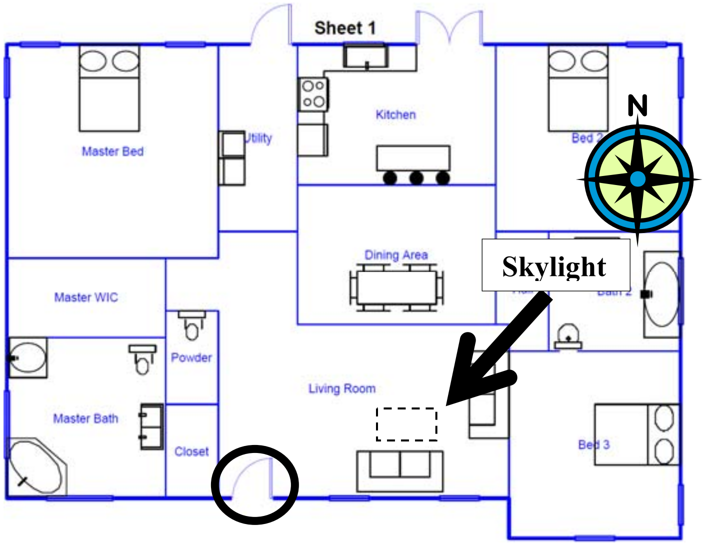

Figure 3: Example Home

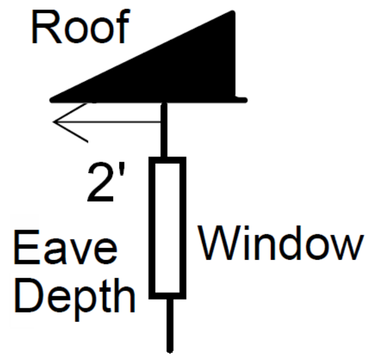

Figure 4: Window

11. Windows Overhang: This value shall represent the deepest overhang. The house may have overhangs of many depths, only the deepest overhang value is recorded. Manual J8: §2-3 (Manual J 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 of two feet.

12. Windows Internal Shade: For an *existing* home this entry must describe the predominate type of internal shading, in a *new* home it describes the expected 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)." Unless there is contrary evidence, HVAC system designers shall default to a "medium color blind with slats at 45 degrees".

Figure 5: Example of Internal Window Shading

13. Skylights (Number): Skylights have a large impact on the heating and cooling load calculations. 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.

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

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, if a 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 (XYZ 080-16, 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 (XYZ 100-16, 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

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

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[1].
       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.

[1] 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.

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.

29. 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.

30. Static Pressure: The design static pressure from the air moving equipment's blower performance table.

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	1484	1282	1077	1402	1200	963	1402	1265	1069	1349	1165	947
0.1	1412	1268	1082	1352	1166	948	1350	1228	1048	1298	1131	915
0.2	1344	1226	1055	1292	1130	924	1289	1180	1015	1243	1090	890
0.3	1277	1171	1013	1227	1089	893	1225	1127	976	1185	1047	866
0.4	1209	1110	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

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[2] 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.

31. 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.

32. 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

33. 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.

34. 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.

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

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

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

36. 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

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

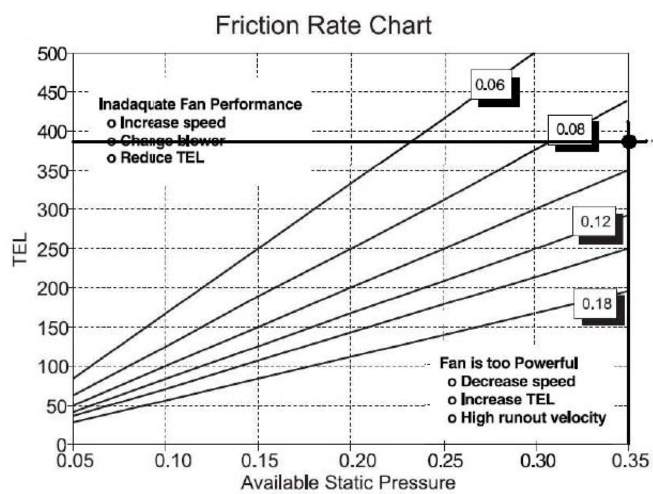

Figure 18: Friction Rate Worksheet - Bottom Section

Duct Materials Used:

37. 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.
38. Branch duct: See item 378.

<u>Examine Duct Distribution Sketch:</u> 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.

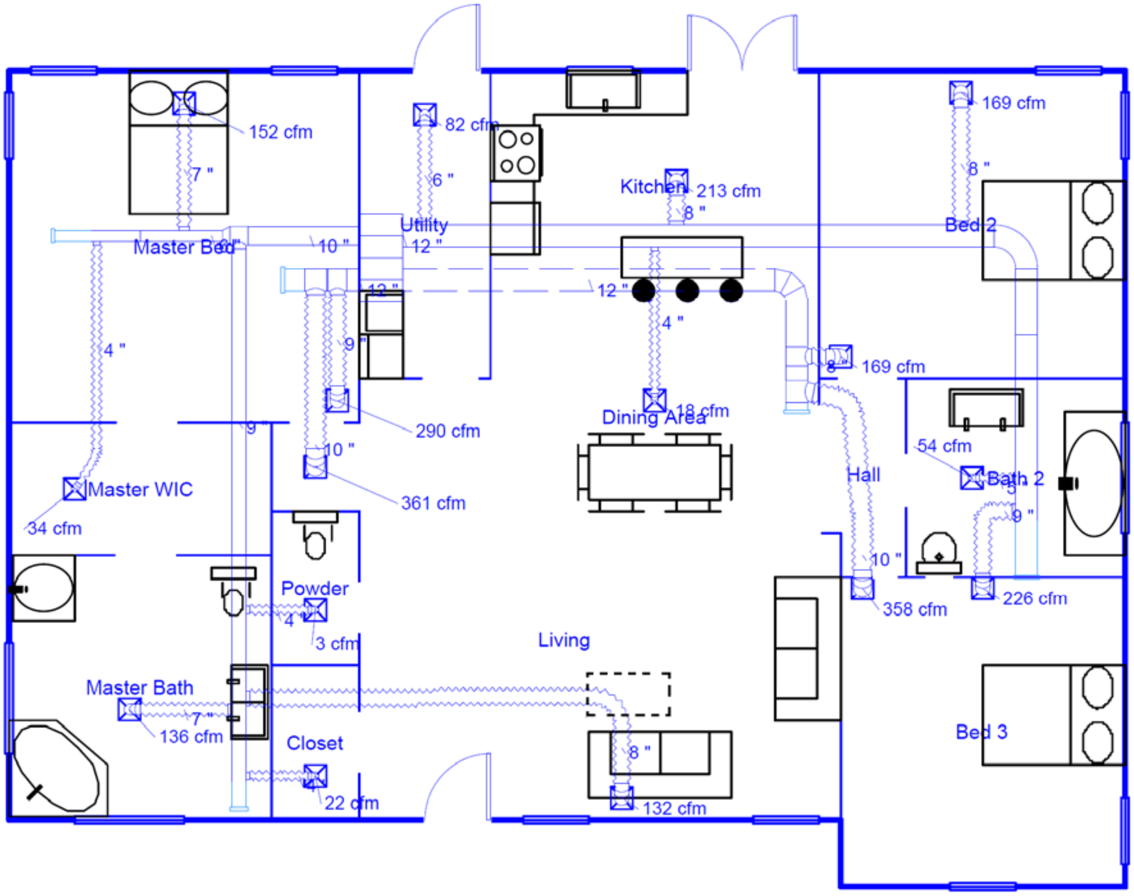

Figure 19: Example Duct Sketch

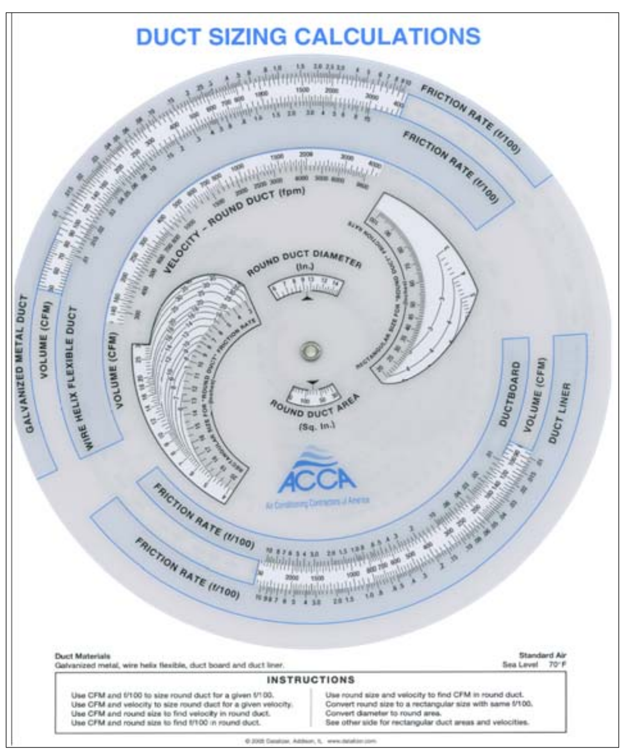

Figure 20: ACCA Duct Calculator

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.