Residential HVAC Design Manual S and D

Residential HVAC Design Manual S and D

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Instructor

<u>Gil Rossmiller</u>

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

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Interactive Class

Please ask questions at any time.

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

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The Code

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

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Why Design ?

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

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Why Design ?

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

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Why Design ? 2021 IRC

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

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Why Design ? 2021 IRC (Deleted in 2027 IRC)

M1401.3 Exceptions

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

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

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

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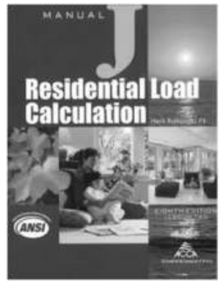
The Residential HVAC Design Process:

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

The entire design process leads to and rests upon the room to room load calculations. It is the Manual J that calculates the homes heating and cooling needs.
(Does the 'Code' require cooling?)



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

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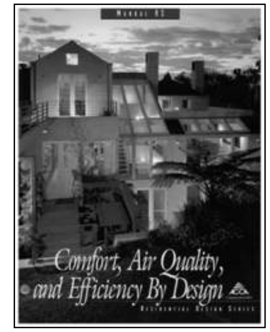
The Residential HVAC Design Process:

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

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



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The Residential HVAC Design Process:

2. Equipment Selection- ACCA Manual S

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

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

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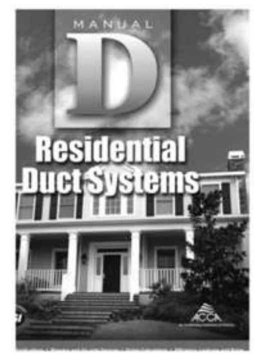
The Residential HVAC Design Process:



3. Duct Design – ACCA Manual D

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

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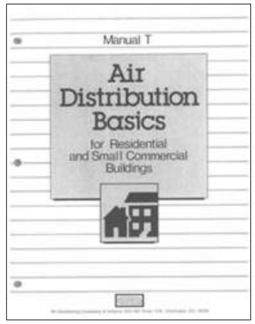
The Residential HVAC Design Process:

4. Room Air Distribution – ACCA Manual T

Selecting the proper sized grilles and registers has its own set of requirements. You could have a properly sized system, perfect equipment, an outstanding duct system and ruin everything with the incorrect grilles and registers.



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The Residential HVAC Design Process:

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

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What is needed for an accurate load calculation?

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

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Loads

Heating	
Basement Windows	5304
First Floor Windows	6365
Basement Walls	4289
Basement Floor	2437
First Floor Walls	4513
First Floor Floors	38
First Floor Doors	1085
First Floor Ceiling	2206
Infiltration	4934
Ventilation	3628
Total	34799

Cooling	Sensible	Latent
Windows	7239	
Opaque Panels	3340	
Infiltration	691	1123
People	1150	1000
Appliances	2400	
Ventilation	960	1560
Blower heat	1707	
Total	17487	3683

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Appliance Selection

Size Limits for Fossil Fuel Furnaces

	Single Stage	Multi Stage	Modulate Burner
Output Capacity for Heating-Only	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
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.		

1) Applies to natural gas, propane, and oil furnaces.
2) Sizing value = MJ8 block load (heating Btuh) for the space served by the equipment.
3) 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.
4) The excess output capacity factor shall range from 1.0 to 1.4 when furnace blower performance is adequate for cooling.
5) 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.
6) Minimum capacity = Sizing value

Table N2-4

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Appliance Selection

***Size Limits* for Water Boilers**
Used for Space Heating Only

Convection Terminals in the Space	*Single-Stage*	*Multi-Stage*	*Modulating Burner*
	Minimum *Heating Size Factor* = 1.00		
	Maximum *Heating Size Factor* = 1.40		

1) Applies to natural gas, propane, oil, and electric heat.
2) Design *capacity* is the *heating load* for the space served by the *equipment*.
3) The minimum output *capacity* is the *heating load*.
4) Excludes steam boilers and solid fuel boilers.

Table N2.6

***Size Limit* for Combination Water Heaters**
Used for Space Heating

Per Section N3 OEM Verification Path

Table N2.7

Size Limits for Fuel-Fired Furnaces

	Single-Stage	*Multi-Stage*	*Modulating Burner*
Output Capacity Fuel-Fired Furnaces: Heating-Only or Heating and Cooling	Minimum *Heating Size Factor* = 1.00		
	Maximum *Heating Size Factor* = 1.40		
	Single-Stage	*Multi-Stage*	*Modulating Burner*
Output Capacity to Meet Cooling Airflow Or Heating Load 25,000 BTU/h or Less	Maximum *Heating Size Factor* = 2.00		Does Not Apply
	Single-Stage	*Multi-Stage*	*Modulating Burner*
Installations Above 2,500 ft	Does Not Apply	Minimum Heating Size Factor = 1.25	Does Not Apply

1) Applies to natural gas, propane, and oil furnaces.
2) The design *capacity* is the *heating load*.
3) The excess output *capacity* factor shall range from 1.0 to 1.4 when the furnace blower performance is adequate for cooling.
4) The 2.0 limit applies when:
   a. The *heating load* is 25,000 BTU/h or less.
   b. When the blower performance from a larger single-stage or multi-stage furnace is required to meet the cooling design airflow.
5) The 2.0 limit shall not apply to single-stage furnaces with zone damper system per Section N2.2.5.
6) For multi-stage equipment installed at elevations above 2,500 feet, the designer shall be permitted to use the low-fire heating capacity to determine the heating size factor.

Table N2.5

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Equipment Selection Heating

Heating	
Basement Windows	5304
First Floor Windows	6365
Basement Walls	4289
Basement Floor	2437
First Floor Walls	4513
First Floor Floors	38
First Floor Doors	1085
First Floor Ceiling	2206
Infiltration	4934
Ventilation	3628
Total	34799

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Equipment Selection Heating

The required load (Heat Loss) on our example house is 34,799 Btuh.

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

This unit has a 40,000 Btuh input rating and has an efficiency rating of 92.3 AFUE.

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Equipment Selection Heating

The output rating will be about 34,799 Btuh after de-rating for efficiency and for altitude.

40,000 x .923 = 36,920 x .90 = 33,228 Btuh

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

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

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

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Equipment Selection Heating

Performance data

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

EFFICIENCY

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

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

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Equipment Selection Heating

Heating Equipment Summary

Make	Carrier	
Trade	Carrier	
Model	58MCB040-12x	
AHRI ref	144278	
Efficiency	92.3	AFUE
Heating input	40000	Btuh
Heating output	36920	Btuh
Temperature rise	42	°F
Actual air flow	830	cfm
Air flow factor	0.034	cfm/Btuh
Static pressure	0.70	in H2O
Space thermostat		

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

ACF: 0.97
36920/830/(1.1 * 0.87)
36920/830/1.067 = 41.68 Round up to 42

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Equipment Selection Heating

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

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Equipment Selection Heating

Heating Equipment Summary

Make	Carrier		
Trade	Carrier		
Model	58MCB040-12x		
AHRI ref	144278		
Efficiency		92.3	AFUE
Heating input		40000	Btuh
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Temperature rise		42	°F
Actual air flow		830	cfm
Air flow factor		0.034	cfm/Btuh
Static pressure		0.70	in H2O
Space thermostat			

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

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Equipment Selection Heating

Performance data

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

AIR DELIVERY—CFM (With Filter)*

UNIT SIZE	RETURN-AIR SUPPLY	SPEED	EXTERNAL STATIC PRESSURE (In. wc) 0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8
040-08	1 side or bottom	High	1075	1040	995	945	895	840	760	670
		Med-Low	850	825	780	740	685	635	560	480
		Low	740	700	650	620	565	515	455	385
040-12	1 side or bottom	High	1470	1415	1400	1285	1215	1120	995	890
		Med-High	1315	1280	1235	1180	1115	1035	930	825
		Med-Low	1125	1110	1085	1045	990	915	830	740
		Low	930	925	910	850	830	770	705	635
060-08	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
060-12	1 side or bottom	High	1430	1375	1325	1275	1200	1135	1040	935
		Med-High	1270	1260	1215	1160	1105	1035	950	850
		Med-Low	1070	1055	1045	1015	975	920	850	750
		Low	915	895	885	865	840	800	720	650
060-16	1 side or bottom	High	1700	1695	1640	1580	1545	1450	1380	1310
		Med-High	1500	1465	1435	1385	1355	1300	1250	1185
		Med-Low	1325	1295	1265	1230	1190	1150	1105	1050
		Low	1205	1170	1145	1110	1080	1035	990	950
080-12	1 side or bottom	High	1535	1470	1405	1330	1245	1160	1065	935
		Med-High	1395	1350	1300	1225	1155	1080	985	880
		Med-Low	1200	1175	1125	1065	1030	970	890	780
		Low	1040	1020	990	960	910	860	785	680
	1 side	High	1750	1685	1635	1575	1525	1445	1380	1310
		Med-High	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

58MCB

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Equipment Selection Heating

Questions on Heating equipment selection ?

Heating Equipment Summary

Make	Carrier		
Trade	Carrier		
Model	58MCB040-12x		
AHRI ref	144278		
Efficiency		92.3	AFUE
Heating input		40000	Btuh
Heating output		36920	Btuh
Temperature rise		42	°F
Actual air flow		830	cfm
Air flow factor		0.034	cfm/Btuh
Static pressure		0.70	in H2O
Space thermostat			

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Equipment Selection Cooling

Size Limits for Cooling-Only Equipment

Equipment Type	Single Speed	Two Speed	Variable Speed See Note 8
	Ducted or Ductless Total Cooling Capacity		
Air-Air	Max = 1.15 Min = 0.90	Max = 1.20 Min = 0.90 FS	Max = 1.30 Min = 0.90 RS
Water-Air pipe loop system	Max = 1.15 Min = 0.90	Max = 1.20 Min = 0.90 FS	Max = 1.30 Min = 0.90 RS
Water-Air open-piping system	Max = 1.25 Min = 0.90	Max = 1.30 Min = 0.90 FS	Max = 1.35 Min = 0.90 RS
Zone Damper Systems	To minimize excess air issues, zone damper systems shall have as little excess cooling capacity as possible when full-cooling capacity is compared to the ***Manual J*** block load for the space served.		

1) This table applies to central ducted equipment, ductless 1:1 split equipment, ductless multi-split equipment, and packaged terminal air conditioning (PTAC) equipment.
2) FS = Full compressor speed; RS = The compressor speed used for the AHRI rating test for advertising total cooling Btuh.
3) OEM expanded performance data for continuous operation, and the operating conditions for a summer design day, determine total cooling capacity, latent capacity, and sensible capacity.
4) Sizing value = MJ8 block load (sensible Btuh plus latent Btuh) for the space served by the equipment.
5) Maximum total cooling capacity = Maximum limit x Sizing value. Minimum total cooling capacity = Minimum limit x Sizing value.
6) The latent capacity value extracted from OEM data shall be equal to, or greater than, the latent load, and should not be more than 150% of the latent load (1.00 to 1.50 factor).
7) Applied sensible capacity (after adjustment for excess latent capacity, where applicable) shall not be less than 90% (0.90 factor) of the sensible load.
8) Maximum equipment size may be determined by the OEM verification path (see Section N3).

Table N2-1

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Standard Sizing Condition Cooling Capacity Size Limits
Air-Air or Water-Air
Single-Speed
Total Cooling Load Less Than or Equal to 24,000 BTU/h
Total Cooling Size Factor ≤ 1.20
Total Cooling Size Factor ≥ 0.90
Sensible Cooling Size Factor ≥ 0.90
Latent Cooling Size Factor ≥ 1.00
Total Cooling Load More Than 24,000 BTU/h
Total Cooling Size Factor ≤ 1.15
Total Cooling Size Factor ≥ 0.90
Sensible Cooling Size Factor ≥ 0.90
Latent Cooling Size Factor ≥1.00
Air-Air or Water-Air
Two-Speed
Total Cooling Size Factor ≤ 1.25
Total Cooling Size Factor ≥ 0.90
Sensible Cooling Size Factor ≥ 0.90
Latent Cooling Size Factor ≥ 1.00

1. Cooling Mode Size *Limits*:
   a. The *total cooling capacity* divided by the cooling load must not exceed the *size limit* in Table N2.3.1, and
   b. The sensible cooling capacity divided by the sensible cooling load must be at least 0.90, and
   c. The latent capacity divided by the latent must be 1.00 or greater.
2. For heat pump *equipment* when *heating capacity* is insufficient to meet the *heating load*, then supplemental heat shall be required. See Section 2.3.1.4

Table N2.3.1

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Equipment Selection Cooling

Cooling	Sensible	Latent
Windows	7239	
Opaque Panels	3340	
Infiltration	691	1123
People	1150	1000
Appliances	2400	
Ventilation	960	1560
Blower heat	1707	
Total	17487	3683

SHR: Sensible Heat Ratio

Sensible load / Total Load

17487/21170 = 0.83

The task is to find the equipment that has the same or very close to the same SHR and meets the calculated load.

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24ABB3
Base™ 13 Air Conditioner
with Puron® Refrigerant

Carrier
Turn to the Experts

Product Data

Puron

INDUSTRY LEADING FEATURES / BENEFITS

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Equipment Selection Cooling

Our target loads:
Total = <u>21,170 Btuh</u> Sensible = <u>17,487 Btuh</u> Latent = <u>3,683 Btuh</u>

DETAILED COOLING CAPACITIES# CONTINUED

EVAPORATOR AIR		CONDENSER ENTERING AIR								
		75 (23.9)			85 (29.4)			95 (35)		
CFM	EWB °F (°C)	Capacity MBtuh Total	Capacity MBtuh Sens‡	Total System KW**	Capacity MBtuh Total	Capacity MBtuh Sens‡	Total System KW**	Capacity MBtuh Total	Capacity MBtuh Sens‡	Total System KW**
24ABB324(A,W)31 Outdoor Section With CAP**24										
700	72 (22.2)	27.09	13.27	1.65	25.82	12.82	1.85	24.63	12.41	2.06
	67 (19.4)	24.89	16.41	1.65	23.63	15.99	1.84	22.71	15.56	2.05
	63 (17.2)††	23.39	15.98	1.64	22.38	15.55	1.84	21.29	15.11	2.05
	62 (16.7)	23.01	19.56	1.64	22.03	19.14	1.84	20.99	18.67	2.05
	57 (13.9)	22.46	22.46	1.64	21.66	21.66	1.83	20.79	20.79	2.05
800	72 (22.2)	27.52	13.92	1.69	26.15	13.46	1.88	24.91	13.04	2.10
	67 (19.4)	25.25	17.44	1.68	24.16	17.03	1.88	23.00	16.60	2.09
	63 (17.2)††	23.76	16.95	1.68	22.72	16.53	1.87	21.60	16.08	2.09
	62 (16.7)	23.47	20.99	1.68	22.49	20.52	1.87	21.52	21.52	2.09
	57 (13.9)	23.30	23.30	1.68	22.44	22.44	1.87	21.53	21.53	2.09

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

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

75° dry bulb at 50% RH is equal to a 62° wet bulb.

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Equipment Selection Cooling

DETAILED COOLING CAPACITIES# CONTINUED

EVAPORATOR AIR		CONDENSER ENTERING AIR								
		75 (23.9)			85 (29.4)			95 (35)		
CFM	EWB °F (°C)	Capacity MBtuh Total	Capacity MBtuh Sensi	Total System KW**	Capacity MBtuh Total	Capacity MBtuh Sensi	Total System KW**	Capacity MBtuh Total	Capacity MBtuh Sensi	Total System KW**
24A[illegible]324(A,W)31 Outdoor Section With CAP**24										
700	72 (22.2)	27.09	13.27	1.85	25.82	12.82	1.85	24.63	12.41	2.06
	67 (19.4)	24.89	16.41	1.85	23.63	15.98	1.84	22.71	15.56	2.05
	63 (17.2)††	23.39	15.58	1.84	22.38	15.55	1.84	21.29	15.11	2.05
	62 (16.7)	23.01	19.56	1.84	22.03	19.14	1.84	20.99	18.67	2.05
	57 (13.9)	22.46	22.46	1.84	21.66	21.66	1.83	20.79	20.79	2.05
800	72 (22.2)	27.52	13.92	1.89	26.15	13.46	1.88	24.91	13.04	2.10
	67 (19.4)	25.25	17.44	1.88	24.16	17.03	1.88	23.00	16.60	2.09
	63 (17.2)††	23.76	16.95	1.88	22.72	16.53	1.87	21.80	16.08	2.09
	62 (16.7)	23.47	20.99	1.88	22.49	20.52	1.87	21.52	21.52	2.09
	57 (13.9)	23.30	23.30	1.88	22.44	22.44	1.87	21.53	21.53	2.08

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

Remember for Kansas City the outdoor design temperature is 92° dry bulb.
Per Manual S we can be within 5°. We will use the 95° value.

At first glance this equipment has a SHR of 16,080 / 21,600 = .74

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

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Equipment Selection Cooling

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

Solve for today's example:

	Sensible	Latent
Total	17487	3683

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

5,520 – 3,683 = 1837/2 = 918   16,080 + 918 = 16,998 new sensible capacity

New SHR 16,998 / 21,600 = 0.79

Per Manual S we can be up to 15% oversized:
Target total load of 21,170 x 1.15 = 24,345 Btuh > 21,600 Btuh

The perfect size system……………

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Equipment Selection Cooling

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

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Equipment Selection Cooling

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

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Equipment Selection Cooling

The formula for air density correction:

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

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

Solve for example house:

- 800/.832 = 962 cfm

Air Density Correction			
Altitude	Density Ratio	Altitude	Density Ratio
1,000	0.964	6,000	0.801
2,000	0.930	7,000	0.772
3,000	0.896	8,000	0.743
4,000	0.864	9,000	0.715
5,000	0.832	10,000	0.687

Table A6-1

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Equipment Selection Cooling

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

AIR DELIVERY—CFM (With Filter)*

UNIT SIZE	RETURN-AIR SUPPLY	SPEED	EXTERNAL STATIC PRESSURE (In. wc)							
			0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8
040-08	1 side or bottom	High	1075	1040	995	945	895	840	760	670
		Med-Low	850	825	780	740	685	635	560	480
		Low	740	700	650	620	565	515	455	385
040-12	1 side or bottom	High	1470	1415	1400	1265	1215	1120	995	890
		Med-High	1315	1280	1235	1180	1115	1035	930	825
		Med-Low	1125	1110	1085	1045	990	915	830	740
		Low	930	925	910	850	830	770	705	635
[illegible]	1 side	High	1100	1065	1005	945	900	805	730	610

We used .7 IWC for heat cfm. It appears if we set the blower at High it will deliver 995 cfm.

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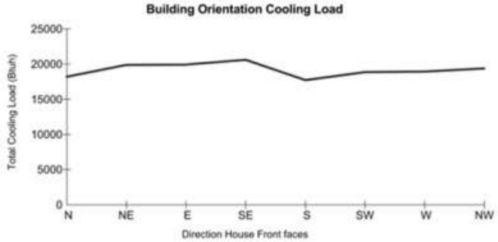
Loads for Multiple Directions

House Front	North	Northeast	East	Southeast	South	Southwest	West	Northwest
Sensible Load (Btuh)	14089	15778	15840	16500	13610	14770	14831	15272
Latent Load (Btuh)	4099	4099	4099	4099	4099	4099	4099	4099
Total Load (Btuh)	18188	19877	19939	20600	17709	18870	18930	19372
Heating AVF (cfm)	830	830	830	830	830	830	830	830
Cooling AVF (cfm)	995	995	995	995	995	995	995	995

Building Orientation Cooling Load



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

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Size Limits for Condition A Heat Pumps JSHR < 0.95; or HDD / CDD < 2.0			
Equipment Type	Single Speed	Two Speed	Variable Speed
	Ducted or Ductless Total Cooling Capacity		
Air-Air	Max = 1.15 Min = 0.90	Max = 1.20 Min = 0.90 FS	Max = 1.30 Min = 0.90 RS
Water-Air pipe loop system	Max = 1.15 Min = 0.90	Max = 1.20 Min = 0.90 FS	Max = 1.30 Min = 0.90 RS
Water-Air open-pipe system	Max = 1.25 Min = 0.90	Max = 1.30 Min = 0.90 FS	Max = 1.35 Min = 0.90 RS

a) Condition A limits are identical to the Table N2-1 limits.
b) Table N2-1 notes 1 through 8 apply to Condition A heat pumps.

Total Cooling Limits for Condition B Heat Pumps JSHR = 0.95 or greater; and HDD / CDD = 2.0 or greater			
Equipment Type	Single Speed	Two Speed	Variable Speed
Air-Air Ducted or Ductless	Max = +15,000 Min = 0.90	Max = +15,000 Min = 0.90 FS	Max = +15,000 Min = 0.90 RS
Water-Air pipe loop system	Max = +15,000 Min = 0.90	Max = +15,000 Min = 0.90 FS	Max = +15,000 Min = 0.90 RS
Water-Air open-pipe system	Max = +15,000 Min = 0.90	Max = +15,000 Min = 0.90 FS	Max = +15,000 Min = 0.90 RS

1) Condition B limits apply to central ducted equipment, ductless 1:1 split equipment, ductless multi-split equipment, and packaged terminal heat pump (PTHP) equipment.
2) JSHR = Sensible cooling load / Total cooling load.
HDD = Heating degree days (65°F).
CDD = Cooling degree days (50°F).
FS = Full-speed; RS = The compressor speed used for the AHRI rating test for advertising total cooling Btuh.
3) OEM expanded performance data and the operating conditions for a summer design day determine total cooling capacity.
4) Sizing value = MJ8 block load (sensible Btuh plus latent Btuh) for space served by the equipment.
5) Maximum total cooling capacity = Sizing value + 15,000 Btuh. Minimum total cooling capacity = 0.90 x Sizing value.
6) Maximum equipment size may be determined by the OEM verification path (see Section N3).

Applies to Condition A and Condition B Applications

a) To minimize excess air issues when zone dampers close, zone damper systems shall have the minimum possible amount of excess cooling capacity when full capacity is compared to the MJ8 block load; and the minimum possible amount of supplemental (electric coil) heating KW when full KW capacity is compared to the supplemental heat load for the balance point diagram.
b) A performance method may be used for multi-speed and variable-speed heat pump sizing. Informative Section A20-6 provides related guidance.

Table N2-2

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Standard Sizing Condition Cooling Capacity Size Limits
Air-Air or Water-Air
Single-Speed
Total Cooling Load Less Than or Equal to 24,000 BTU/h
Total Cooling Size Factor ≤ 1.20
Total Cooling Size Factor ≥ 0.90
Sensible Cooling Size Factor ≥ 0.90
Latent Cooling Size Factor ≥ 1.00
Total Cooling Load More Than 24,000 BTU/h
Total Cooling Size Factor ≤ 1.15
Total Cooling Size Factor ≥ 0.90
Sensible Cooling Size Factor ≥ 0.90
Latent Cooling Size Factor ≥1.00
Air-Air or Water-Air
Two-Speed
Total Cooling Size Factor ≤ 1.25
Total Cooling Size Factor ≥ 0.90
Sensible Cooling Size Factor ≥ 0.90
Latent Cooling Size Factor ≥ 1.00

1. Cooling Mode Size *Limits*:
   a. The *total cooling capacity* divided by the cooling load must not exceed the *size limit* in Table N2.3.1, and
   b. The sensible cooling capacity divided by the sensible cooling load must be at least 0.90, and
   c. The latent capacity divided by the latent must be 1.00 or greater.
2. For heat pump *equipment* when *heating capacity* is insufficient to meet the *heating load*, then supplemental heat shall be required. See Section 2.3.1.4.

Table N2.3.1

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Carrier

Product Data

38BYC (60 Hz)
12 SEER Heat Pump

Sizes 018 thru 060

FEATURES/BENEFITS

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Variable-Capacity Equipment Sizing Condition *Single-Split System* (Ducted or Ductless) and Multi-Split Outdoor Unit Air-Air and Water-Air *Equipment*
Simplified Cooling Only
Total Cooling Size Factor ≤ 1.30
Total Cooling Size Factor ≥ 0.90
Latent Cooling Size Factor ≥ 1.00
Simplified Heat Pump
Simplified Cooling Requirements Apply
Heating Size Factor ≥ 1.00
Minimum Compressor Heating Size Factor ≤ 0.80
Advanced Heat Pump
Minimum Compressor Cooling Size Factor ≤ 0.80
Minimum compressor Latent Cooling Size Factor ≥ 1.00
Heating Size Factor ≥ 1.00
Minimum Compressor Heating Size Factor ≤ 0.80
Advanced Dry Heat Pump JSHR ≥ 0.95 or *Active Dehumidification*
Minimum Compressor Cooling Size Factor ≤ 0.80
Heating Size Factor ≥ 1.00
Minimum Compressor Heating Size Factor ≤ 0.80

1. Simplified procedure - cooling-only *size limits*:
   a. The *total cooling capacity* divided by the *cooling load* is the *total cooling size factor*, which must 1.30 or less, and
   b. The *latent cooling capacity* divided by the *latent load* is the *latent cooling size factor*, which must be greater than or equal to 1.00.
2. Simplified procedure - heat pump *size limits*:
   a. Shall meet the cooling-only *size limits* for cooling, and
   b. The *heating capacity* divided by the *heating load*, which is the *heating size factor*, shall be greater than or equal to 1.00, and
   c. The minimum compressor *heating capacity* divided by the *heating load*, which is the *minimum compressor heating size factor*, shall be 0.80 or less.
3. *Advanced heat pump sizing limits*:
   a. The *minimum compressor cooling capacity* divided by the *total cooling load*, which is the *minimum compressor cooling size factor*, must be less than or equal to 0.80, and
   b. The *minimum compressor latent capacity* divided by the *latent load*, which is the *minimum compressor latent cooling size factor*, must be greater than or equal to 1.00, and
   c. The *heating capacity* divided by the *heating load*, which is the *heating size factor*, shall be greater than or equal to 1.00, and,
   d. The *minimum compressor heating capacity* divided by the *heating load*, which is the *minimum compressor heating size factor*, shall be less than or equal to 0.80.
4. Advanced dry heat pump *size condition* requires a Manual J *sensible heat ratio* of 0.95 or greater, or *active dehumidification*.
5. Advanced dry heat pump *size limits*:
   a. The *minimum compressor cooling capacity* divided by the *total cooling load*, which is the *minimum compressor cooling size factor*, shall be less than or equal to 0.80, and
   b. The *heating capacity* divided by the *heating load*, which is the *heating size factor*, shall be greater than or equal to 1.00, and
   c. The *minimum compressor heating capacity* divided by the *heating load*, which is the *minimum compressor heating size factor*, shall be less than or equal to 0.80, and
   d. The heat pump heating capacity at 47°F divided by the *heating load* shall be less than or equal to 1.50.

Table N2.3.4

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Size Limits for Water Boilers
Used for Space Heating-Only

The sizing value is for the load on gravity or forced convection terminals in the space, and / or hot water coils in an air distribution system.	Single Stage	Multi Stage	Modulating Output
	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

Size Limits for Duct or Air Handler Water Coils

The sizing value is for the load on a hot water coil in an air distribution system.	Two-Position Valve	Throttling Value
	Sizing value to 1.25 x Sizing value	Sizing value to 1.5 x Sizing value

Size Limits for Water Heaters Used for Space Heat

A water heater that provides closed-circuit space heat shall also provide potable water heat. Section N2-10 summarizes code requirements. Also refer to design and sizing guidance proved by the equipment manufacturer.

1) Applies to natural gas, propane, oil, and electric heat.
2) When the boiler or water heater provides potable water heat and/or snow melting heat, in addition to space heat, refer to code guidance, OEM guidance, and trade association guidance that pertains to such applications.
3) Sizing value = MJ8 block load (heating Btuh) for the space served by the equipment.
4) Minimum capacity = Sizing value.

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2027 IRC

Size Limits for Water Boilers Used for Space Heating Only			
Convection Terminals in the Space	*Single-Stage*	*Multi-Stage*	*Modulating Burner*
	Minimum *Heating Size Factor* = 1.00		
	Maximum *Heating Size Factor* = 1.40		

1) Applies to natural gas, propane, oil, and electric heat.
2) Design *capacity* is the *heating load* for the space served by the *equipment*.
3) The minimum output *capacity* is the *heating load*.
4) Excludes steam boilers and solid fuel boilers.

Table N2.6

Size Limit for Combination Water Heaters Used for Space Heating
Per Section N3 OEM Verification Path

Table N2.7

Appliance/Equipment Selection Questions?

Residential HVAC Design Duct Design
Manual D

Why Design ? 2021 IRC

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

2021 IRC

M1601.4.1 Joints, seams and connections

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

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2021 IRC

M1601.4.1 Joints, seams and connections

Exceptions:

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

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

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

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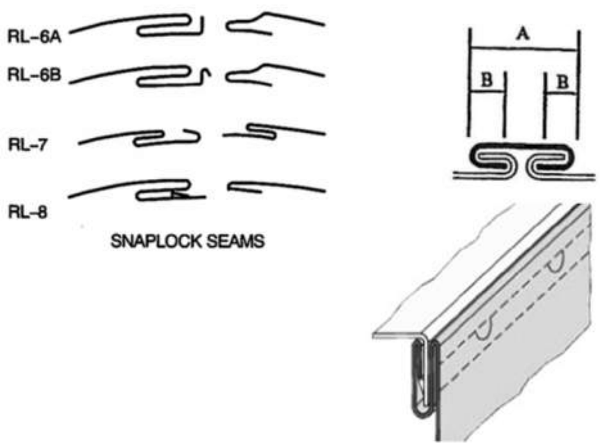

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2021 IRC

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

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

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2021 IRC

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

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

Exception:

~~1. Duct tightness test is not required if the air handler and all ducts are located within conditioned space.~~

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

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

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2021 IRC

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

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

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

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54

2021 IRC

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

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2021 IRC

N1103.2.3 Building Cavities (Mandatory). Building framing cavities shall not be used as ducts or plenums.

In Contrast……..

M1601.1.1 Above-ground duct systems

Above-ground duct systems shall conform to the following:

7. Stud wall cavities and the spaces between solid floor joists to be used as air plenums shall comply with the following conditions:

7.1. These cavities or spaces shall not be used as a plenum for supply air.

7.2. These cavities or spaces shall not be part of a required fire-resistance-rated assembly.

7.3. Stud wall cavities shall not convey air from more than one floor level.

7.4. Stud wall cavities and joist-space plenums shall be isolated from adjacent concealed spaces by tight-fitting fireblocking in accordance with Section R602.8.

7.5. Stud wall cavities in the outside walls of building envelope assemblies shall not be utilized as air plenums.

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Why Design ?

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Manual D Duct Sizing

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

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

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

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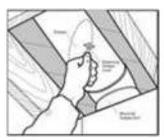
Manual D Duct Sizing

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

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



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Manual D Duct Sizing

Steps in duct design:

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

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Manual D Duct Sizing

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

See how easy it is!!!!

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Manual D Duct Sizing

A reasonably well designed system will be within these parameters:

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

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Manual D Duct Sizing

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

Copy of Table 3-1 from ACCA Manual D

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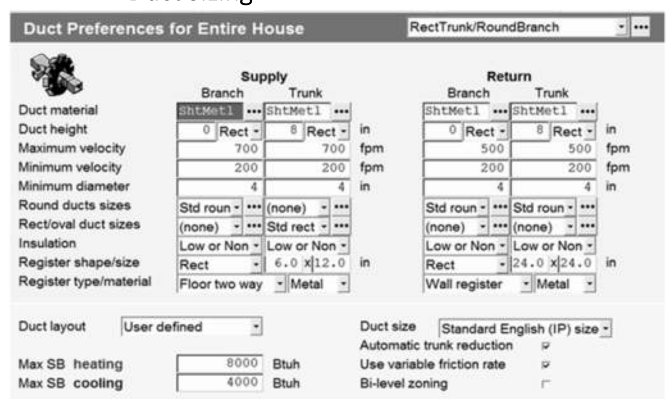
Manual D Duct Sizing



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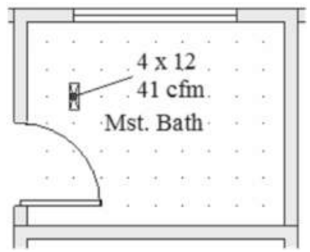
Manual D Duct Sizing

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



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Manual D Duct Sizing

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

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

Solve for today's house
- Heating Factor = 830 ⁄ 24,390 = .034
- Cooling Factor = 995 ⁄ 12,453 = .080

Design Information

Weather: Kansas City Intl, MO, US

Winter Design Conditions

Outside db	2	°F
Inside db	70	°F
Design TD	68	°F

Summer Design Conditions

Outside db	93	°F
Inside db	75	°F
Design TD	18	°F
Daily range	M	
Relative humidity	50	%
Moisture difference	47	gr/lb

Heating Summary

Structure	24390	Btuh
Ducts	0	Btuh
Central vent (62 cfm)	4418	Btuh
Outside air		
Humidification	0	Btuh
Piping	0	Btuh
Equipment load	28807	Btuh

Sensible Cooling Equipment Load Sizing

Structure	12453	Btuh
Ducts	0	Btuh
Central vent (62 cfm)	1157	Btuh
Outside air		
Blower	0	Btuh
Use manufacturer's data	y	
Rate/swing multiplier	1.00	
Equipment sensible load	13610	Btuh

Infiltration

Method	Simplified	
Construction quality	Average	
Fireplaces	0	

	Heating	Cooling
Area (ft²)	3699	3699
Volume (ft³)	15355	15355
Air changes/hour	0.28	0.15
Equiv. AVF (cfm)	72	38

Latent Cooling Equipment Load Sizing

Structure	2190	Btuh
Ducts	0	Btuh
Central vent (62 cfm)	1909	Btuh
Outside air		
Equipment latent load	4099	Btuh
Equipment Total Load (Sen+Lat)	17709	Btuh
Req. total capacity at 0.85 SHR	1.3	ton

Heating Equipment Summary

Make	Carrier	
Trade	Carrier	
Model	58MCB040-12x	
AHRI ref	144278	
Efficiency	92.3 AFUE	
Heating input	40000	Btuh
Heating output	36920	Btuh
Temperature rise	42	°F
Actual air flow	830	cfm
Air flow factor	0.034	cfm/Btuh
Static pressure	0.70	in H2O
Space thermostat		

Cooling Equipment Summary

Make	Carrier	
Trade	BASE 13 PURON AC	
Cond	24ABB324(A,W)31	
Coil	CAP**2414A**+TDR	
AHRI ref	3250356	
Efficiency	11.0 EER, 13 SEER	
Sensible cooling	18835	Btuh
Latent cooling	2765	Btuh
Total cooling	21600	Btuh
Actual air flow	995	cfm
Air flow factor	0.080	cfm/Btuh
Static pressure	0.70	in H2O
Load sensible heat ratio	0.77	

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Manual D Duct Sizing

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

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

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Manual D Duct Sizing

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

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Manual D Duct Sizing

Static Pressure for Entire House

	Heating (in H2O)	Cooling (in H2O)
External static pressure	[0.70]	[0.70]
Pressure losses		
Coil	0.20	0.30
Heat exchanger	0	0
Supply diffusers	0.03	0.03
Return grilles	0.03	0.03
Filter	0.10	0.10
Humidifier	0	0
Balancing damper	0	0
Other device	0	0
Available static pressure	0.34	0.24

	Supply (ft)	Return (ft)
Measured length of run-out	12	12
Measured length of trunk	28	6
Equivalent length of fittings	170	105
Total length	210	123
Total effective length		333

Friction Rate	Heating (in/100ft)		Cooling (in/100ft)	
Supply	[0.102]	OK	[0.072]	OK
Return	[0.102]	OK	[0.072]	OK

69

Manual D Duct Sizing

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

Where:

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

Solve:

.29 x 100 ⁄ 305 = .095

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

70

Manual D Duct Sizing

Supply Branches for Entire House

Heating friction rate 0.102 in/100ft

Cooling friction rate 0.072 in/100ft

Duct Tree

Duct name	ST	RB	Heat Btuh	Cool Btuh		Ds. flow (cfm)	STEL (ft)	Pr. drop (in H2O)	Veloc (fpm)		Diam (in)	H x W (in)		Matl
Recreation	st2	rb1	1593	674	h	54	169	0.21	398	p	5.0	0	0	ShMt
Recreation-A	st1	rb1	1593	674	h	54	192	0.21	398	p	5.0	0	0	ShMt
Recreation-B	st2A	rb1	1593	674	h	54	161	0.21	398	p	5.0	0	0	ShMt
Bed 1-A	st2A	rb5	1685	1387	c	111	160	0.21	415	p	7.0	0	0	ShMt
Bed 3	st1A	rb1	1519	368	h	52	210	0.21	379	p	5.0	0	0	ShMt
Bed 4	st1	rb1	1378	985	c	79	191	0.21	354	p	5.6	8	4	ShMt
Dining	st1A	rb6	952	866	c	69	192	0.21	353	p	6.0	0	0	ShMt
Kitchen	st1	rb5	1366	1412	c	113	194	0.21	422	p	7.0	0	0	ShMt
Kitchen-A	st1A	rb6	1366	1412	c	113	199	0.21	422	p	7.0	0	0	ShMt
Laundry	st2	rb5	587	258	c	21	167	0.21	237	p	4.0	0	0	ShMt
Living-A	st1	rb5	2134	724	h	73	196	0.21	370	p	6.0	0	0	ShMt
Living-B	st1	rb6	2134	724	h	73	197	0.21	370	p	6.0	0	0	ShMt
Master Bedroom	st2	rb3	1816	901	c	72	172	0.21	367	p	6.0	0	0	ShMt
Master Bedroom-A	st2	rb3	1816	901	c	72	147	0.21	367	p	6.0	0	0	ShMt
Mst. Bath	st1	rb3	1066	317	h	36	200	0.21	416	p	4.0	0	0	ShMt
Powder	st1	rb5	702	176	h	24	113	0.21	107	s	3.0	8	4	ShMt

71

Manual D Duct Sizing

Duct preferences for today's house

Fitting Preferences

Elbows		
Metal	Rect supp	8B3
	Round supp	8AE
	Rect ret	8B3
	Round ret	8AE
Flex		11I

Takeoffs		
Supply	Rect	2H1
	Round	2J0
Return	Rect	6B1
	Round	6C3

72

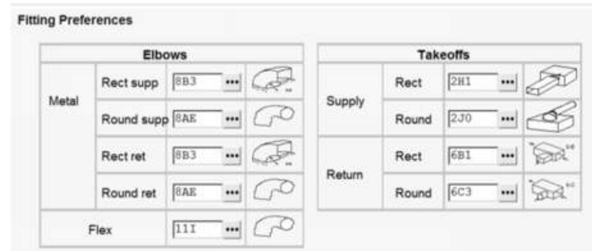
Manual D Duct Sizing

Duct preferences for today's house

73

73

Manual D Duct Sizing



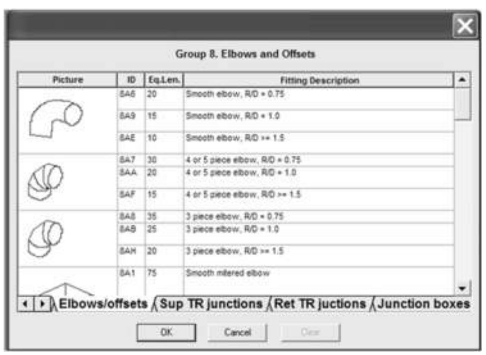
- Note: Round Supply 8AE

74

74

Manual D Duct Sizing

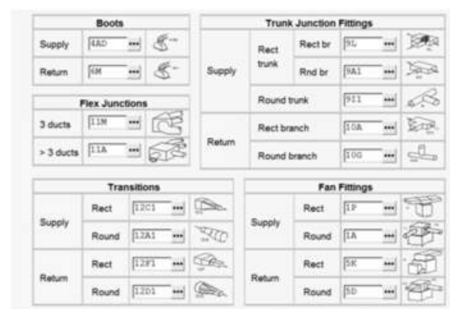
Equivalent lengths for elbows and offsets.



75

75

Manual D Duct Sizing

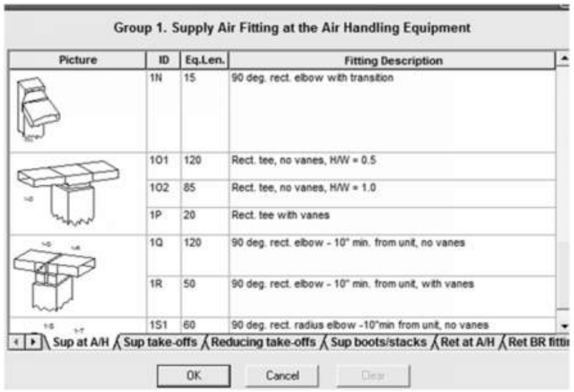


- Note: Supply Fan Fitting 1P

76

76

Manual D Duct Sizing

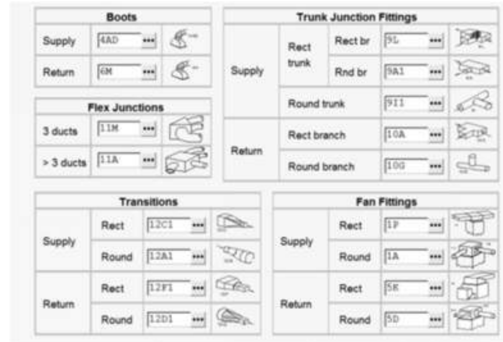


Group 1. Supply Air Fitting at the Air Handling Equipment

Picture	ID	Eq.Len.	Fitting Description
	1N	15	90 deg. rect. elbow with transition
	1O1	120	Rect. tee, no vanes, H/W = 0.5
	1O2	85	Rect. tee, no vanes, H/W = 1.0
	1P	20	Rect. tee with vanes
	1Q	120	90 deg. rect. elbow - 10" min. from unit, no vanes
	1R	50	90 deg. rect. elbow - 10" min. from unit, with vanes
	1S1	60	90 deg. rect. radius elbow -10"min from unit, no vanes

77

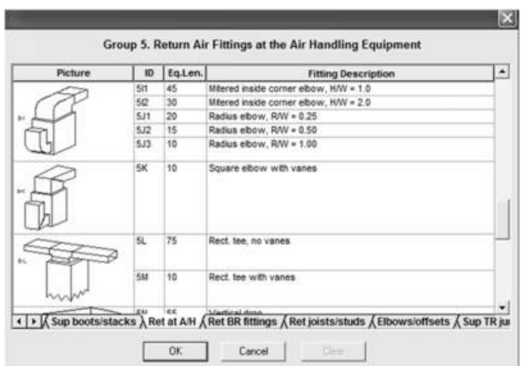
Manual D Duct Sizing



- Note: Supply Fan Fitting 5K

78

Manual D Duct Sizing

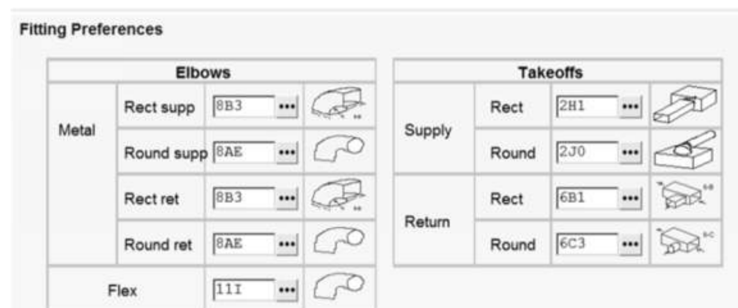


Group 5. Return Air Fittings at the Air Handling Equipment

Picture	ID	Eq.Len.	Fitting Description
	5I1	45	Mitered inside corner elbow, H/W = 1.0
	5I2	30	Mitered inside corner elbow, H/W = 2.0
	5J1	20	Radius elbow, R/W = 0.25
	5J2	15	Radius elbow, R/W = 0.50
	5J3	10	Radius elbow, R/W = 1.00
	5K	10	Square elbow with vanes
	5L	75	Rect. tee, no vanes
	5M	10	Rect. tee with vanes

79

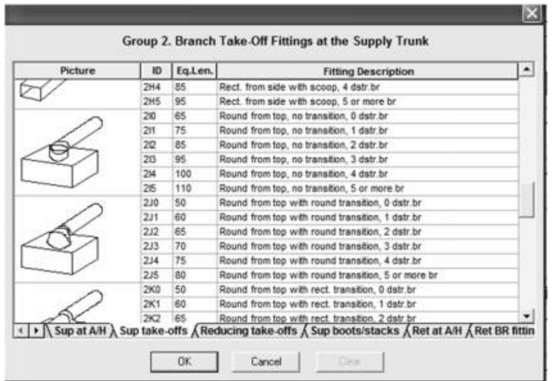
Manual D Duct Sizing



- Note: Round Supply 2JO

80

Manual D Duct Sizing



Group 2. Branch Take-Off Fittings at the Supply Trunk

Picture	ID	Eq.Len.	Fitting Description
	2H4	85	Rect. from side with scoop, 4 dstr.br
	2H5	95	Rect. from side with scoop, 5 or more br
	2I0	65	Round from top, no transition, 0 dstr.br
	2I1	75	Round from top, no transition, 1 dstr.br
	2I2	85	Round from top, no transition, 2 dstr.br
	2I3	95	Round from top, no transition, 3 dstr.br
	2I4	100	Round from top, no transition, 4 dstr.br
	2I5	110	Round from top, no transition, 5 or more br
	2J0	50	Round from top with round transition, 0 dstr.br
	2J1	60	Round from top with round transition, 1 dstr.br
	2J2	65	Round from top with round transition, 2 dstr.br
	2J3	70	Round from top with round transition, 3 dstr.br
	2J4	75	Round from top with round transition, 4 dstr.br
	2J5	80	Round from top with round transition, 5 or more br
	2K0	50	Round from top with rect. transition, 0 dstr.br
	2K1	60	Round from top with rect. transition, 1 dstr.br
	2K2	65	Round from top with rect. transition, 2 dstr.br

Sup at A/H | Sup take-offs | Reducing take-offs | Sup boots/stacks | Ret at A/H | Ret BR fittin

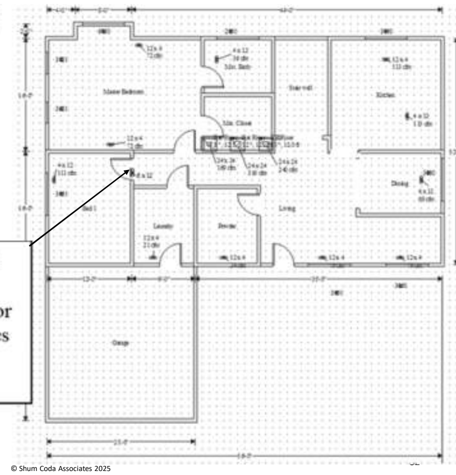
OK Cancel

 81

81

Manual D Duct Sizing

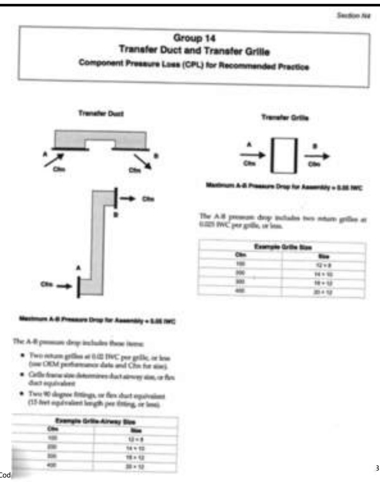
Today's House



A return air duct is not required to each room; however, a return air path is required. This could be a 'jumper duct' or a transfer grille. Room to room pressures should not exceed plus or minus 3 pa. (Pascals)

82

Manual D Pg. N43



83

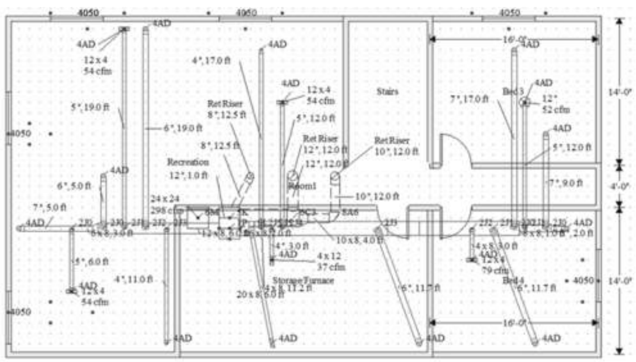
Manual D Pg.13

Minimum Door Undercut Gap							
Cfm Under Door	Door Width (Inches)						
	24	30	36	42	48	54	60
	Clearance (Inches) to Floor or Top of Carpet						
100	2.0	1.6	1.3	1.1	1.0	0.9	0.8
200	4.0	3.2	2.7	2.3	2.0	1.8	1.6
300	6.0	4.8	4.0	3.4	3.0	2.7	2.4
400	8.0	6.4	5.3	4.6	4.0	3.6	3.2
500	10.0	8.0	6.7	5.7	5.0	4.4	4.0
600	12.0	9.6	8.0	6.9	6.0	5.3	4.8
700	14.0	11.2	9.3	8.0	7.0	6.2	5.6
800	16.0	12.8	10.7	9.1	8.0	7.1	6.4
900	18.0	14.4	12.0	10.3	9.0	8.0	7.2
1,000	20.0	16.0	13.3	11.4	10.0	8.9	8.0
1,200	24.0	19.2	16.0	13.7	12.0	10.7	9.6
1,400	28.0	22.4	18.7	16.0	14.0	12.4	11.2
1,600	32.0	25.6	21.3	18.3	16.0	14.2	12.8
Door gap height based on 300 Fpm air velocity though the gap.							

Table N3-2

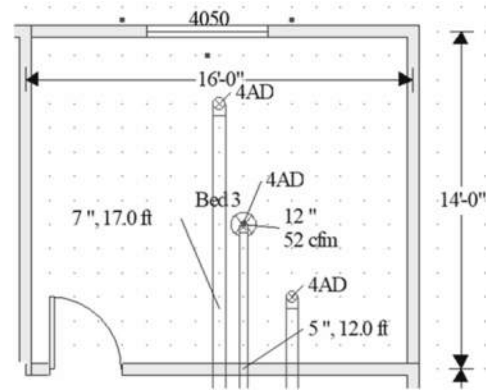
84

Manual D
Duct Sizing Today's House

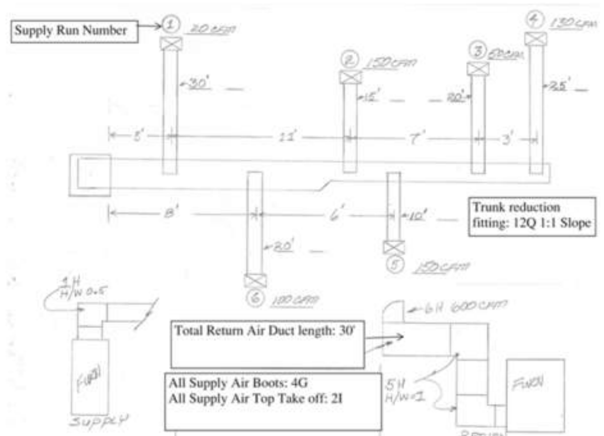


85

Manual D Duct Sizing



86



87

Manual D Duct Sizing

Friction Rate Worksheet

Step 1) Manufacturer's Blower Data

External static pressure (ESP) = .7 IWC Cfm = 600

Step 2) Component Pressure Losses (CPL)

Direct expansion refrigerant coil	.25
Electric resistance heating coil	
Hot water coil	
Heat exchanger	
Low efficiency filter	
High or mid-efficiency filter	.1
Electronic filter	
Humidifier	
Supply outlet	.03
Return grille	.03
Balancing damper	.03
UV lights or other component	
Total component losses (CPL)	.44 IWC

Step 3) Available Static Pressure (ASP)

ASP = (ESP - CPL) = (.7 .44) = .26 IWC

Step 4) Total Effective Length (TEL)

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

Step 5) Friction Rate Design Value (FR)

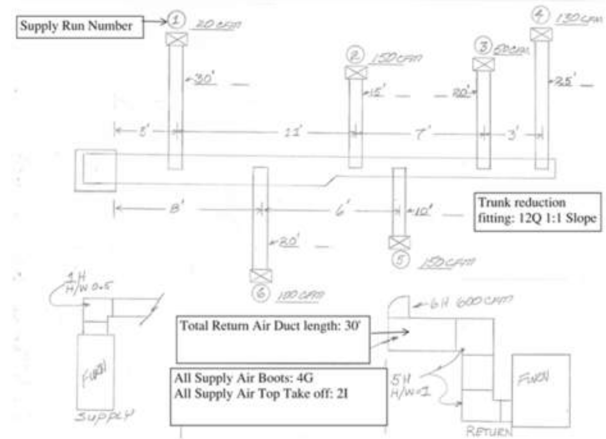
FR value from friction rate chart = ______ IWC/100

88

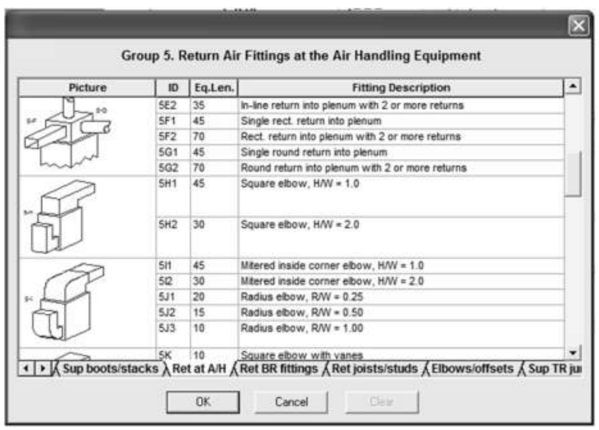
Effective Length Worksheet

Element	Supply Run ID Number			Element	Return Run ID Number		
Trunk Length				Trunk Length			
Trunk Length				Trunk Length			
Trunk Length				Trunk Length			
Runout Length				Runout Length			
Group 1				Group 5			
Group 2				Group 6			
Group 3				Group 7			
Group 4				Group 8			
Group 8				Group 10			
Group 9				Group 11			
Group 11				Group 12			
Group 12				Group 13			
Group 13				Other			
Other				Other			
Total Length				Total Length			

89



90



Group 5. Return Air Fittings at the Air Handling Equipment

ID	Eq.Len.	Fitting Description
5E2	35	In-line return into plenum with 2 or more returns
5F1	45	Single rect. return into plenum
5F2	70	Rect. return into plenum with 2 or more returns
5G1	45	Single round return into plenum
5G2	70	Round return into plenum with 2 or more returns
5H1	45	Square elbow, H/W = 1.0
5H2	30	Square elbow, H/W = 2.0
5I1	45	Mitered inside corner elbow, H/W = 1.0
5I2	30	Mitered inside corner elbow, H/W = 2.0
5J1	20	Radius elbow, R/W = 0.25
5J2	15	Radius elbow, R/W = 0.50
5J3	10	Radius elbow, R/W = 1.00
5K	10	Square elbow with vanes

Sup boots/stacks | Ret at A/H | Ret BR fittings | Ret joists/studs | Elbows/offsets | Sup TR ju

OK Cancel Clear

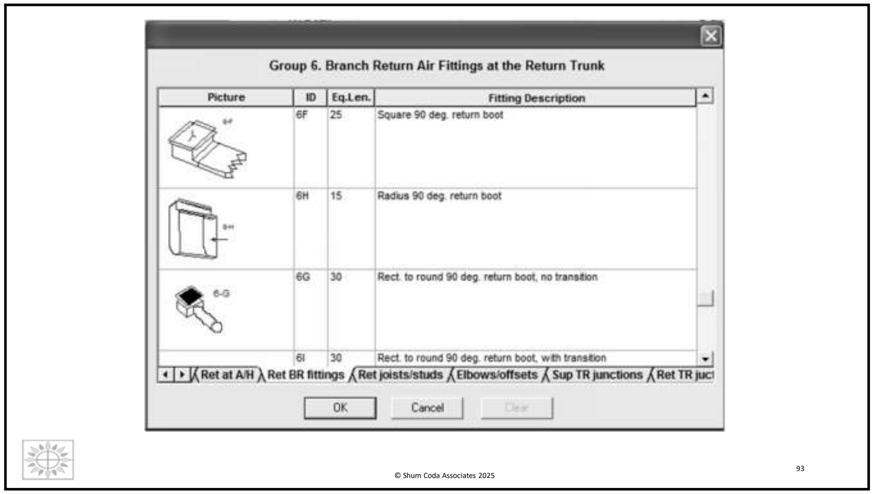
91

Manual D Duct Sizing

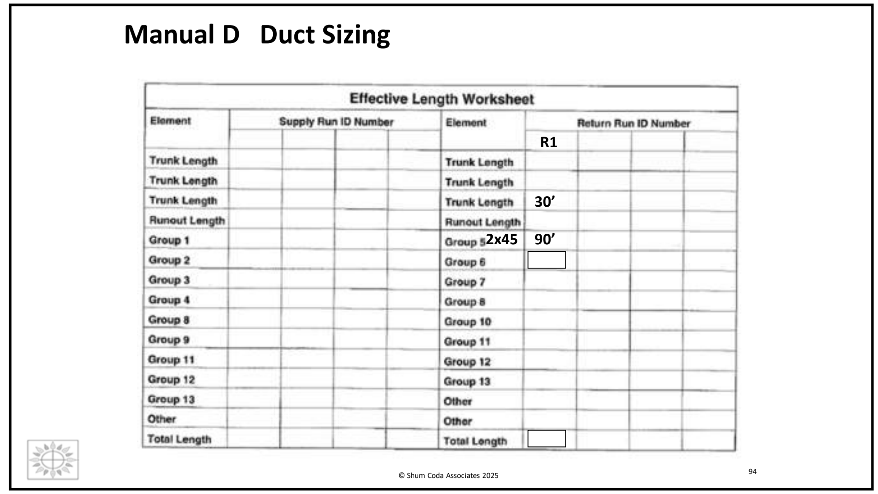
Effective Length Worksheet

Element	Supply Run ID Number				Element	Return Run ID Number			
Trunk Length					Trunk Length				
Trunk Length					Trunk Length				
Trunk Length					Trunk Length				
Runout Length					Runout Length				
Group 1					Group 5				
Group 2					Group 6				
Group 3					Group 7				
Group 4					Group 8				
Group 8					Group 10				
Group 9					Group 11				
Group 11					Group 12				
Group 12					Group 13				
Group 13					Other				
Other					Other				
Total Length					Total Length				

92



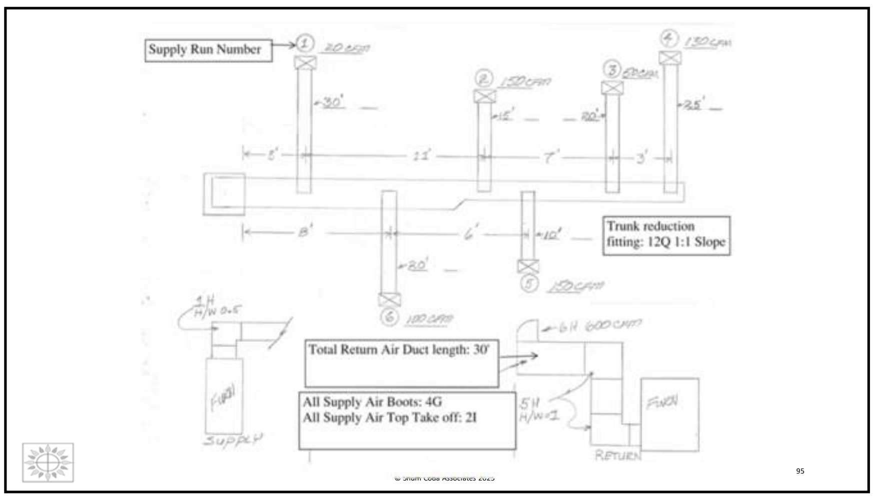
93



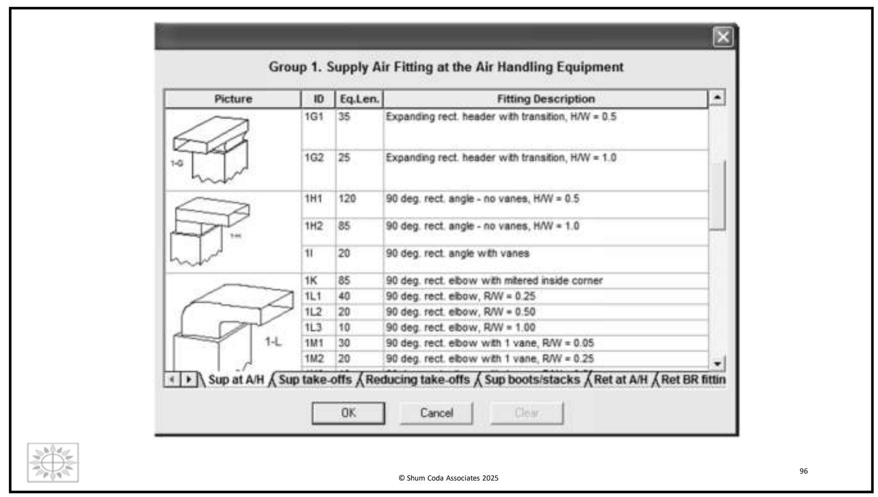
Effective Length Worksheet

Element	Supply Run ID Number				Element	Return Run ID Number			
						R1			
Trunk Length					Trunk Length				
Trunk Length					Trunk Length				
Trunk Length					Trunk Length	30'			
Runout Length					Runout Length				
Group 1					Group 5 2x45	90'			
Group 2					Group 6				
Group 3					Group 7				
Group 4					Group 8				
Group 8					Group 10				
Group 9					Group 11				
Group 11					Group 12				
Group 12					Group 13				
Group 13					Other				
Other					Other				
Total Length					Total Length				

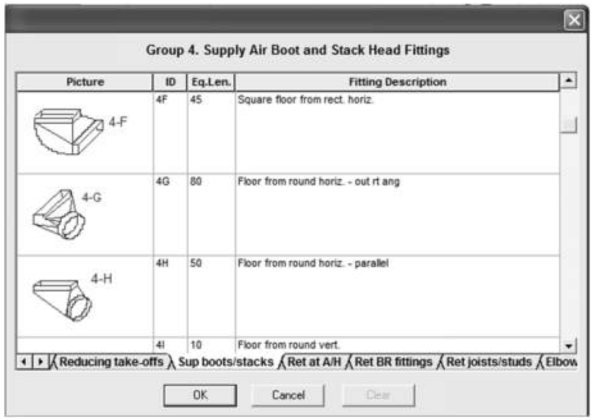
94



95



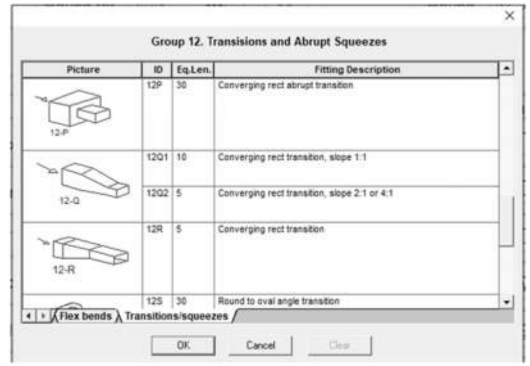
96



Group 4. Supply Air Boot and Stack Head Fittings

Picture	ID	Eq.Len.	Fitting Description
4-F	4F	45	Square floor from rect. horiz.
4-G	4G	80	Floor from round horiz. – out rt ang
4-H	4H	50	Floor from round horiz. – parallel
	4I	10	Floor from round vert.

97



Group 12. Transitions and Abrupt Squeezes

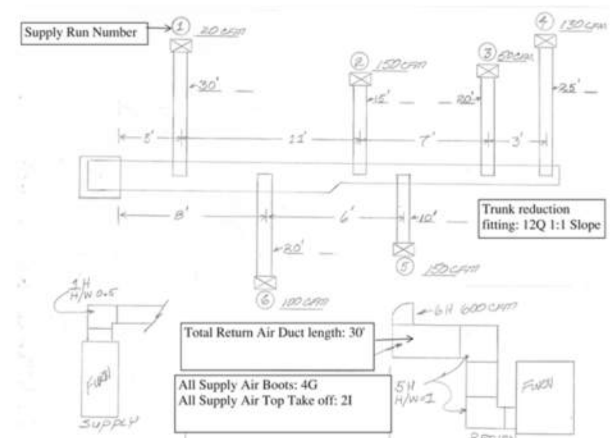
Picture	ID	Eq.Len.	Fitting Description
12-P	12P	30	Converging rect abrupt transition
12-Q	12Q1	10	Converging rect transition, slope 1:1
	12Q2	5	Converging rect transition, slope 2:1 or 4:1
12-R	12R	5	Converging rect transition
	12S	30	Round to oval angle transition

98

Effective Length Worksheet

Element	Supply Run ID Number				Element	Return Run ID Number			
						R1			
Trunk Length					Trunk Length				
Trunk Length					Trunk Length				
Trunk Length					Trunk Length	30'			
Runout Length					Runout Length				
Group 1					Group 5 2x45	90'			
Group 2					Group 6	15'			
Group 3					Group 7				
Group 4					Group 8				
Group 8					Group 10				
Group 9					Group 11				
Group 11					Group 12				
Group 12					Group 13				
Group 13					Other				
Other					Other				
Total Length					Total Length	135'			

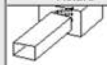
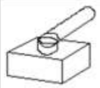
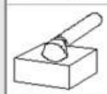
99



Hando

100

Group 2. Branch Take-Off Fittings at the Supply Trunk

Picture	ID	Eq.Len.	Fitting Description
	2H2	70	Rect. from side with scoop, 2 dstr.br
	2H3	75	Rect. from side with scoop, 3 dstr.br
	2H4	85	Rect. from side with scoop, 4 dstr.br
	2H5	95	Rect. from side with scoop, 5 or more br
	2I0	65	Round from top, no transition, 0 dstr.br
	2I1	75	Round from top, no transition, 1 dstr.br
	2I2	85	Round from top, no transition, 2 dstr.br
	2I3	95	Round from top, no transition, 3 dstr.br
	2I4	100	Round from top, no transition, 4 dstr.br
	2I5	110	Round from top, no transition, 5 or more br
	2J0	50	Round from top with round transition, 0 dstr.br
	2J1	60	Round from top with round transition, 1 dstr.br
	2J2	65	Round from top with round transition, 2 dstr.br
	2J3	70	Round from top with round transition, 3 dstr.br
	2J4	75	Round from top with round transition, 4 dstr.br
	2J5	80	Round from top with round transition, 5 or more br
	2K0	50	Round from top with rect. transition, 0 dstr.br

Sup at A/H | Sup take-offs | Reducing take-offs | Sup boots/stacks | Ret at A/H | Ret BR fittin

OK Cancel Clear

101

Effective Length Worksheet

Element	Supply Run ID Number				Element	Return Run ID Number			
	2	3	4	5		R1			
Trunk Length					Trunk Length				
Trunk Length					Trunk Length				
Trunk Length					Trunk Length	30’			
Runout Length					Runout Length				
Group 1	120’	120’	120’	120’	Group 5 2x45	90’			
Group 2					Group 6	15’			
Group 3					Group 7				
Group 4	80’	80’	80’	80’	Group 8				
Group 8					Group 10				
Group 9					Group 11				
Group 11					Group 12				
Group 12 ? 10’					Group 13				
Group 13					Other				
Other					Other				
Total Length					Total Length	135’			

102

Friction Rate Worksheet

Step 1) Manufacturer's Blower Data

External static pressure (ESP) = .7 IWC Cfm = 600

Step 2) Component Pressure Losses (CPL)

Direct expansion refrigerant coil	.25
Electric resistance heating coil	
Hot water coil	
Heat exchanger	
Low efficiency filter	.1
High or mid-efficiency filter	
Electronic filter	
Humidifier	
Supply outlet	.03
Return grille	.03
Balancing damper	.03
UV lights or other component	

Total component losses (CPL) .44 IWC

Step 3) Available Static Pressure (ASP)

ASP = (ESP - CPL) = (.7 - .44) = .26 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

103

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

Where:

ASP = Available static pressure

100 = The friction rate is per 100’ of duct length

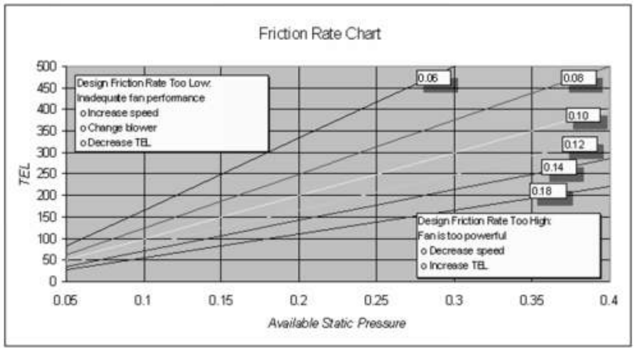
TEL = Total Equivalent Length of ductwork

Solve:

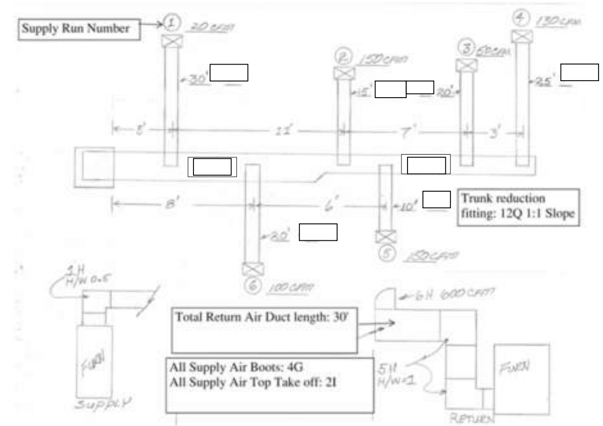
.26 x 100 ⁄ 471 = 0.055

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

104



105



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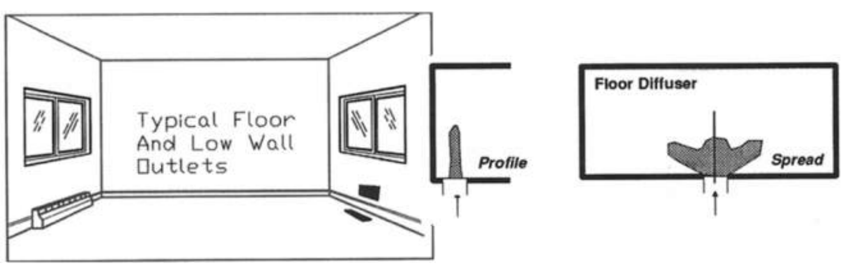
Manual T



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

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9-8 Acceptable NC for Various Applications

Some examples of of recommended NC levels for various applications are shown by the table below. Basically these recommendations take the ambient noise into consideration. Noise produced by the air conditioning equipment is acceptable as long as it is "masked" by the ambient noise.

Application	NC Level	Maximum Velocity
Private Residence		
Rural/Suburban	20 to 25	700
Urban	25 to 30	700
Apartments	30 to 35	700
Hotels/Motels		
Private room or suite	30 to 35	700
Meeting/Banquet room	30 to 35	700
Halls, Corredors, Lobbies	35 to 40	800
Service and support areas	40 to 45	900
Offices		
Executive	25 to 30	700
Conference rooms	25 to 30	700
Private	30 to 35	700
Open bay areas	35 to 40	800
Computer room	35 to 40	900
Business machine room	40 to 45	900
Waiting rooms	40 to 45	900
Retail Stores		
Clothing department	35 to 40	800
General sales areas	40 to 50	900
Supermarkets	40 to 50	900
Hospitals and Clinics		
Private/Semi-private rooms	25 to 30	700
Operating Rooms	25 to 30	700
Wards	30 to 35	700
Churches and Schools		
Sanctuaries	20 to 30	700
Libraries	30 to 35	700
Classrooms	30 to 35	700

9-9 Face Velocity Guidelines

Rather than providing specific NC ratings, many manufacturers provide face velocity or neck velocity guidelines for various applications. A listing of the maximum recommended velocity is also provided by the table below.

Application	NC Level	Maximum Velocity
Churches and Schools (cont)		
Laboratories	35 to 40	800
Gyms and rec. areas	40 to 50	900
Kitchens	40 to 50	900
Public Assembly		
Concert halls	20 to 25	700
Legitimate theaters	20 to 25	700
Auditoriums	25 to 30	700
Motion picture theatres	30 to 35	700
Libraries/Museums/Courts	30 to 35	700
Coliseums	30 to 35	700
Bank/Post office	35 to 40	800
Lobbies	35 to 40	800
Swimming pools	40 to 55	1000
Transportation Terminals		
Ticketing areas	30 to 35	700
General Waiting	35 to 45	800
Studios		
Recording studios	20 to 25	700
Broadcasting studios	20 to 25	700
TV audience studios	30 to 35	700
Restaurants/Cafeterias/Lounges		
Restaurant eating area	35 to 40	800
Lounges	35 to 45	800
Night clubs	35 to 45	800
Cafeterias	40 to 50	900
Industrial Production Areas	Background Noise Sets Limits	

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Hart and Cooley

420/421 Floor Diffuser (Page 5)

Face Velocity		300	400	500	600	700	800	900	1000
Pressure Loss		.006	.010	.016	.022	.031	.040	.050	.062
2 x 10 Ak .085	CFM		35	45	50	60	70	75	85
	Spread		3.0	5.0	5.0	6.0	7.0	8.0	9.0
	Throw		4.0	4.5	6.0	7.0	8.0	9.0	10.0
2 x 12 Ak .100	CFM	30	40	50	60	70	80	90	100
	Spread	3.0	4.0	4.5	5.5	6.5	7.0	8.0	9.0
	Throw	3.5	4.5	5.5	7.0	8.0	9.0	10.0	11.0
2 x 14 Ak .115	CFM	35	45	60	70	80	90	105	115
	Spread	3.5	4.0	5.0	7.0	7.0	8.0	9.0	10.0
	Throw	3.5	4.5	6.0	8.0	8.0	9.5	10.5	12.0
4 x 8 Ak .130	CFM	40	50	65	80	90	105	115	130
	Spread	3.0	4.0	5.0	6.5	7.5	8.5	9.5	11.0
	Throw	4.0	4.5	6.0	7.5	8.5	10.0	11.0	13.0
4 x 10 Ak .170	CFM	50	70	85	100	120	135	155	170
	Spread	4.5	5.0	6.5	7.5	9.0	10.0	11.5	13.0
	Throw	4.0	6.0	8.0	10.0	11.0	12.5	14.0	15.5
4 x 12 Ak .195	CFM	60	80	100	120	140	160	175	195
	Spread	5.0	6.5	8.0	9.5	11.5	13.0	14.5	16.0
	Throw	4.0	5.5	7.0	8.0	9.5	11.0	12.0	13.0
4 x 14 Ak .230	CFM	70	90	115	140	160	185	205	230
	Spread	5.5	7.0	8.5	10.0	12.0	13.5	15.5	17.0
	Throw	4.5	5.5	7.0	8.5	10.0	11.5	12.5	14.0
6 x 10 Ak .240	CFM	70	95	120	145	170	190	215	240
	Spread	5.5	7.0	8.0	10.0	12.0	14.0	15.0	17.0
	Throw	4.0	5.5	7.0	8.5	10.0	11.0	12.5	14.0
6 x 12 Ak .285	CFM	85	115	140	170	200	230	255	285
	Spread	6.0	7.5	9.0	11.0	13.0	15.0	17.0	19.0
	Throw	4.5	6.0	7.5	9.0	10.0	12.0	14.0	16.0
6 x 14 Ak .330	CFM	100	130	165	200	230	265	300	330
	Spread	6.5	8.0	9.0	12.0	14.0	16.5	18.0	20.0
	Throw	4.5	6.5	8.0	9.5	11.0	13.0	15.0	17.0

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Hart and Cooley

672/674 Return Air Grille (Page 20, 10)
673 Return Air Filter Grille (Page 20)

Face Velocity*		300	400	500	600
6 x 4 Ak .110	CFM	34	45	56	68
	Ps	.020	.035	.054	.079
6 x 6 Ak .170	CFM	50	67	84	101
	Ps	.019	.035	.054	.079
8 x 4 Ak .150	CFM	45	60	75	90
	Ps	.019	.035	.054	.079
8 x 6 Ak .220	CFM	67	89	111	134
	Ps	.019	.035	.054	.079
8 x 8 Ak .300	CFM	89	118	148	178
	Ps	.019	.035	.054	.078
10 x 4 Ak .190	CFM	56	74	93	112
	Ps	.019	.035	.054	.079
10 x 6 Ak .280	CFM	83	111	139	167
	Ps	.019	.035	.054	.078
10 x 8 Ak .370	CFM	111	147	184	221
	Ps	.019	.034	.054	.078
10 x 10 Ak .460	CFM	138	184	230	276
	Ps	.019	.034	.054	.078
12 x 6 Ak .330	CFM	100	133	166	199
	Ps	.019	.034	.054	.078
12 x 8 Ak .440	CFM	132	177	221	265
	Ps	.019	.034	.054	.078
12 x 10 Ak .550	CFM	165	220	275	330
	Ps	.019	.034	.053	.077
12 x 12 Ak .660	CFM	197	263	329	395
	Ps	.019	.034	.053	.077
12 x 18 Ak .980	CFM	294	392	491	589
	Ps	.019	.034	.053	.075
14 x 6 Ak .390	CFM	116	155	193	232
	Ps	.019	.034	.054	.078
14 x 8 Ak .510	CFM	154	205	257	308
	Ps	.019	.034	.053	.077
14 x 10 Ak .640	CFM	192	256	320	384
	Ps	.019	.034	.053	.077
14 x 12 Ak .770	CFM	230	306	383	460
	Ps	.019	.034	.053	.076
14 x 14 Ak .890	CFM	267	357	446	535
	Ps	.019	.034	.053	.075
14 x 18 Ak 1.140	CFM	343	457	571	685
	Ps	.019	.033	.052	.074

Face Velocity*		300	400	500	600
16 x 6 Ak .440	CFM	132	177	221	265
	Ps	.019	.034	.054	.078
16 x 8 Ak .590	CFM	176	234	293	352
	Ps	.019	.034	.053	.077
16 x 10 Ak .730	CFM	219	292	365	438
	Ps	.019	.034	.053	.076
16 x 12 Ak .870	CFM	262	349	437	524
	Ps	.019	.034	.053	.076
16 x 14 Ak 1.020	CFM	305	407	509	610
	Ps	.019	.034	.052	.075
16 x 16 Ak 1.160	CFM	348	464	580	696
	Ps	.019	.033	.052	.074
16 x 24 Ak 1.730	CFM	519	692	865	1038
	Ps	.018	.033	.051	.071
16 x 25 Ak 1.800	CFM	540	720	900	1081
	Ps	.018	.033	.051	.071
18 x 6 Ak .500	CFM	149	198	248	297
	Ps	.019	.034	.054	.077
18 x 18 Ak 1.460	CFM	439	585	732	878
	Ps	.019	.033	.052	.073
18 x 24 Ak 1.940	CFM	583	777	971	1166
	Ps	.018	.032	.051	.070
20 x 6 Ak .550	CFM	165	220	275	330
	Ps	.019	.034	.053	.077
20 x 10 Ak .910	CFM	273	364	455	546
	Ps	.019	.034	.053	.075
20 x 12 Ak 1.090	CFM	327	435	544	653
	Ps	.019	.033	.052	.074
20 x 14 Ak 1.270	CFM	380	507	634	760
	Ps	.019	.033	.052	.074
20 x 20 Ak 1.800	CFM	540	720	900	1081
	Ps	.018	.033	.051	.071
20 x 24 Ak 2.160	CFM	647	862	1078	1293
	Ps	.018	.032	.050	.069
20 x 25 Ak 2.240	CFM	673	898	1122	1346
	Ps	.018	.032	.050	.069

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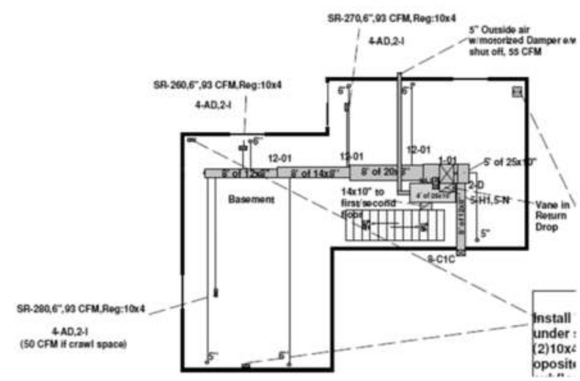
Field Inspections

What is needed?
1. Duct Plan
2. Fittings used
3. Equipment Selection



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Field Inspections

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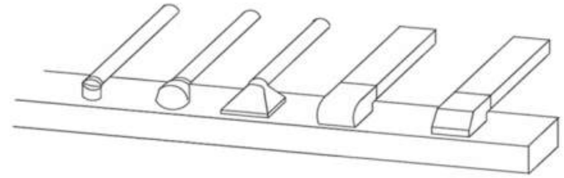
Field Inspections



EL Values		Number of Downstream Branches to End of Trunk Duct or Number of Downstream Branches to a Trunk Reducer					
Fitting		0	1	2	3	4	5 or More
	2I	65	75	85	95	100	110
	2J	50	60	65	70	75	80
	2K	50	60	65	70	75	80
	2L	70	80	90	95	105	115
	2M	70	80	90	95	105	115

Note: If the trunk has a reducer, count down to the reducer; then begin a new count after the reducer.

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Square Elbow with Vanes 5K	EL
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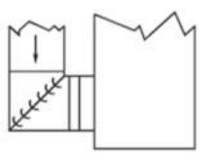
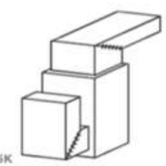
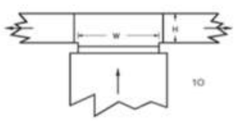
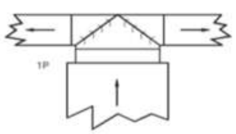






Bull Head No Vanes 1O	H / W	EL
	0.50	120
	1.0	85



Vaned Tee 1P	EL = 20

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Field Inspections

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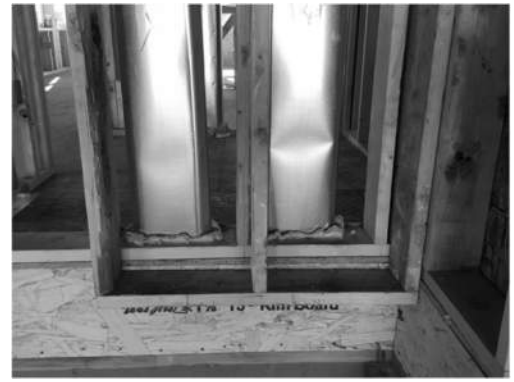
Field Inspections



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Field Inspections

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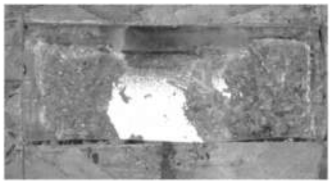

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Field Inspections

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Field Inspections

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System Verification with Testing

Duct leakage test

Test pressure is 25pa
Can be pressurized or depressurized

Typical leak areas
- Top take off
- Boots
- Connection to furnace
- Furnace itself

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System Verification with Testing

Static Pressure Test

Probe in return air drop

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System Verification with Testing

Static Pressure Test

Probe is below the coil

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System Verification with Testing

Static Pressure Test

Reading
Supply .263 in.wc.
Return .0789 in.wc.
Total system static .3419 in.wc.

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System Verification with Testing

- Flow Hood
- Measures CFM

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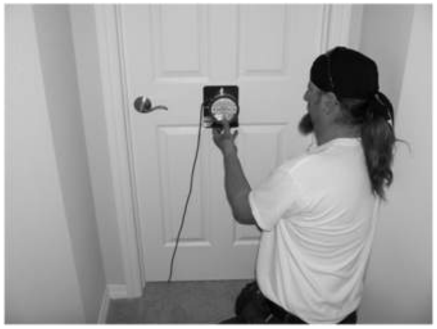
System Verification with Testing



- Room to Room Pressures
- Should be within + - 3pa

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System Verification with Testing

- Blower Door
- Depressurizes house to 50pa
- A blower door and duct tightness test are used simultaneously to measure duct leakage outside the buildings thermal envelope

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Questions ??

Answers !!!

Thank You !!

Contact Information:
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