Sizing Ducts in Residential HVAC Systems: A Quick Guide for Contractors

One of the biggest mistakes made when sizing a duct in a residential HVAC system is not realizing how airflow through the duct affects and is affected by the entire system. You cannot accurately size one duct without knowing the load and airflow of the entire system. Changing one duct can change the airflow in all ducts.

Designing a new duct system is easier than sizing a duct to be added to an existing system. This Quick Guide focuses on sizing an entire duct system with the assumption the system includes air conditioning. Most of the time, a system properly sized for air conditioning will work fine for heating, and better still if you slightly increase the heating fan speed.

THE PROCESS

The basic steps to design a typical ducted central system for a home are:

1. Collect information about the house
2. Perform room-by-room load calculations
3. Select equipment to meet loads
4. Design distribution system

This Quick Guide focuses on Step 4. Steps 1, 2, and 3 are summarized below.

Step 1. Collect information about the house

If you are designing a system for a new house, most of the information can be found in the building plans, including: floor area, wall area, roof area, window area and orientation, door area, and other surfaces that conduct heat.

If you are designing a system for an existing house, you may have to create floor plans based on field measurements.

Step 2. Perform room-by-room load calculations

There are two types of load calculations. The first type is a whole house load calculation that assigns one number for the entire house (or zone) to select the equipment size. The second type is a room-by-room load calculation, which divides the house into rooms and calculates a heating and cooling load per room. Room-by-room load calculations are *critical* for designing a distribution system.

Written and published by Air Conditioning Contractors of America (ACCA), the *ACCA Manual J* is the industry standard for performing load calculations.

Step 3. Select Equipment to Meet Loads

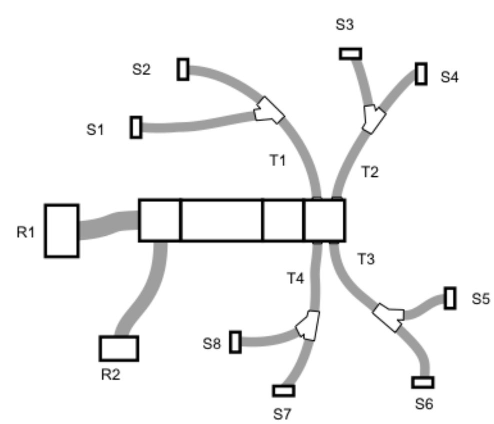
The *ACCA Manual S* is the industry standard for equipment selection. It provides easy to follow instructions on how to determine *actual* output of an air conditioner at design conditions. For sizing heat pumps, refer to *ACCA Manual H*.

Step 4. Design the Distribution System

Designing the distribution system is one of the most overlooked aspects of HVAC design. Historically, designers and installers relied on rule of thumb or trial and error. Now, the *ACCA Manual D* is the industry standard for residential duct design.

The design is not difficult to implement as long as you have room-by-room load calculations or some other way to attribute the loads to each room. Getting a proportional amount of air distributed per room's load is called "air balance."

Consider the following simple layout:



Source: "HVAC 1.0 – Introduction to Residential HVAC Systems," Russell King, P.E.

The room-by-room cooling loads (performed in Step 2) are as follows.

ROOM	LOAD
S1	2600
S2	1800
S3	3800
S4	2700
S5	3500
S6	4600
S7	900
S8	4100
	24000

These numbers are rounded to the nearest hundred to simplify the math. In an actual scenario, the numbers would be more precise (e.g., 1237 rather than 1200).

Next, to determine the percent-of-total load for each room, divide a single room's load by the total load. This value can be in decimal or a percent format.

For example: 2600 / 24000 = 0.108 or 10.8%.

ROOM	LOAD	% OF TOTAL
S1	2600	0.108
S2	1800	0.075
S3	3800	0.158
S4	2700	0.113
S5	3500	0.146
S6	4600	0.192
S7	900	0.038
S8	4100	0.171
	24000	1

Airflow must be distributed proportionally to each room's load. To calculate the proportional amount of CFM per room, multiply the percent-of-total load by the total airflow. For example, assuming the equipment selected delivers 1000 CFM of total airflow: 0.108 x 1000 CFM = 108 CFM. Check your work by adding up the CFM per room and comparing it to the total CFM (should be the same).

ROOM	LOAD	% OF TOTAL	CFM
S1	2600	0.108	108
S2	1800	0.075	75
S3	3800	0.158	158
S4	2700	0.113	113
S5	3500	0.146	146
S6	4600	0.192	192
S7	900	0.038	38
S8	4100	0.171	171
	24000	1	1000

As shown in the first row of the table, in order to maintain comfort balance in the house, room S1, must be at least 108 CFM out of a total of 1000, and so on.

Refer to Manual D for information on how to determine friction rate. A friction rate of 0.1 is common for simple layouts like the one shown. More complex layouts will often have friction rates of 0.08 or lower. The friction rate should be calculated for each system. Bent or sagging ducts will reduce airflow and increase friction loss. To prevent higher friction loss, you must install the ducts short and straight. Otherwise, consider moving up to the next duct diameter.

Assuming a friction rate of 0.1, we can use this table to size the ducts:

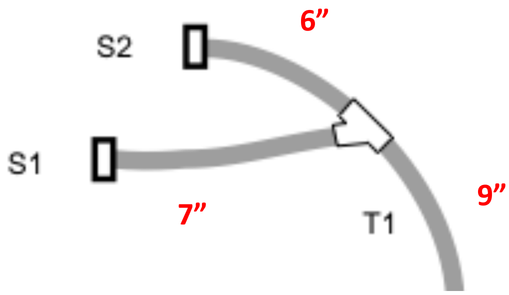
Duct Diameter	Air Flow CFM
4"	20
5"	50
6"	80
7"	120
8"	170
9"	230
10"	300
12"	500
14"	740
16"	1050
18"	1400
20"	1875

Select the size of duct that provides the next largest airflow. For example if you need 89 CFM, then select a 7" duct (a 6" duct will only give you 80 CFM). You can always make small adjustments later.

ROOM	LOAD	% OF TOTAL	CFM	DUCT DIA
S1	2600	0.108	108	7
S2	1800	0.075	75	6
S3	3800	0.158	158	8
S4	2700	0.113	113	7
S5	3500	0.146	146	8
S6	4600	0.192	192	9
S7	900	0.038	38	5
S8	4100	0.171	171	9
	24000	1	1000	

Here are the results.

The next step is to size the trunks. Add the target airflows of the branches downstream then select the size of duct that provides the next largest airflow. For example: T1 serves S1 and S2, so it needs to be sized to provide at least 183 CFM (108 + 75 CFM); which is a 9" duct. The t-wye will be a 9-7-6, not a very common fitting, but if a contractor wants to use standard sizes, it would have to be a 10-8-6.



Here are the trunk sizes.

TRUNKS		CFM	DUCT DIA
T1	S1 + S2 =	183	9
T2	S3 + S4 =	271	10
T3	S5 + S6 =	338	12
T4	S7 + S8 =	208	9

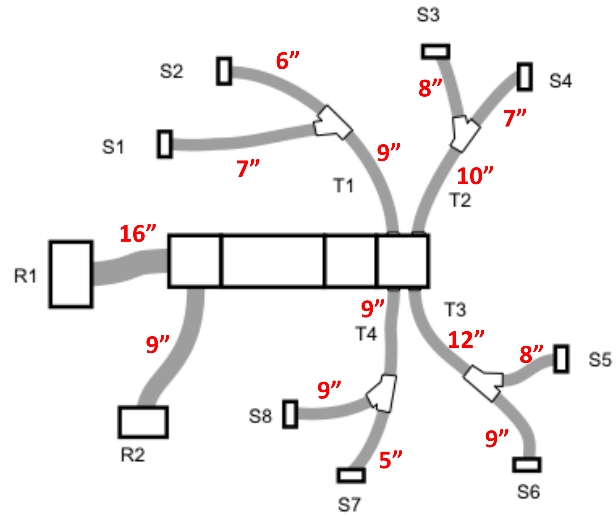
The next step is to size the return ducts. Assign supply registers to each return. This is fairly arbitrary. Just determine which air is most likely to be drawn toward which return. If a return is behind a closeable door, then supplies on that side of the door should be assigned to it. Also, upstairs supply air should be assigned to upstairs returns and downstairs supply air should be assigned to downstairs returns, but this is not mandatory.

In this example, the master bathroom S7 and the master bedroom S8 are assigned to return, R2; which is inside the master bedroom. The remainder supply registers are assigned to return, R1. The return ducts are sized the same as the supply trunks.

Here are the return duct sizes.imit

RETURNS		CFM	DUCT DIA
R1	S1 +S2 +S3 + S4 + S5 + S6 =	792	16
R2	S7 + S8 =	208	9

Here is the final layout.



Note that some of the t-wyes are incorrectly drawn. Usually, the larger duct is in-line with the trunk, and the smaller duct branches off at an angle. The drawing can be fine-tuned after you determine the duct sizes. Different style fittings can also be used depending on your preference (duct board boxes, pants, etc.).

SOURCE:

“HVAC 1.0 – Introduction to Residential HVAC Systems,” Russell King, P.E.

ACCA Manual D

FOR MORE INFORMATION

For more information about energy efficiency incentives available through SMUD, visit: ***http://hpp.smud.org/*** or email Jim Mills at: ***james.mills@smud.org***

For more information about improving airflow and duct sizing refer to:

ACCA Manual D, www.acca.org