DESIGN PROCESS FOR SIZING COOLING AND HEATING SYSTEM CAPACITY, ROOM AIR FLOWS, DUCTS, AND TRANSFERS

A design process is laid out for sizing cooling and heating system capacity, and for specifying the airflow and duct sizes to each conditioned space, and for specifying the free area needed to transfer air supplied to closed rooms back to the central return. This design process involves using the industry standard ACCA Manual J calculation procedure with specific parameters specified to properly handle infiltration, ventilation, glazing, and airflow velocities for ducts for the Building America houses.

Six of eight floor plans being used at the Creek Bend Estates subdivision were evaluated. The program RHVAC from EliteSoft was used, which follows ACCA Manual J. A spreadsheet collated the information from EliteSoft and performed additional calculations to come up with the final specifications.

When setting up the building model, some specific parameters need to be input properly for evaluation of the Building America (BA) houses.

Infiltration

All of the BA houses are constructed to have a low building envelope air leakage rate and have a controlled mechanical ventilation system installed. The ventilation system slightly pressurizes the house when the air handler unit blower is operating. During that time, a small amount of conditioned air leaves the building through unintentional leakage pathways to outside, restricting air exchange to exfiltration not infiltration. While the air handler unit blower is not operating, some air infiltration will occur. Based on tracer gas measurements in many of the homes constructed to the Building America standard, the infiltration rate should be input as 0.1 air changes per hour for winter and summer.

Ventilation

Then, the design ventilation rate is input according to equation (1) given above. The ventilation rate is usually about 80 cfm for a three bedroom house.

Glazing

The spectrally selective glazing used in the BA homes has a Solar Heat Gain Coefficient (SHGC) of 0.37 as rated and labeled by the National Fenestration Research Council. The RHVAC program does not allow input for SHGC, rather it allows for various inputs whose product is the older Shading Coefficient (SC) input. Equation (2) is an approximate conversion from SHGC to SC. Therefore, the SC is 0.43 for an SHGC of 0.37. The appropriate inputs to get the desired SC of 0.43 are glazing type 3A, Shade Screen Coefficient set to 0.50, no interior shading, and a glass type of clear.

$$SHGC = 0.86SC \qquad (2)$$

Air Flow Velocity

When setting up criteria for the mechanical system, some velocity constraints and duct size constraints should be set to obtain appropriate duct sizing from the program. Set the supply trunk velocity range to 500 ft/min to 750 ft/min. Set the supply runout maximum velocity to 500 ft/min. Set the runout duct type to round flex and the minimum runout duct diameter to 4". Set the return air trunk maximum velocity to 350 ft/min.

As an example to illustrate this design process, the results for Plan 4244 are given in Figures 2 and 3.

Pulte Houston, Creek Bend, Manual J system sizing and duct sizing results

Plan 4244

	Orientation of Front of House									
	N	NE	E	SE	S	SW	W	NW	max	avg
	RHVAC program output									
Heating Load (kBtu/h)	27.9									**BSC**
Sensible Cooling Load (kBtu/h)	26.0		28.2		25.5		28.3			**Spec**
Latent Cooling Load (kBtu/h)	3.7		3.7		3.7		3.7			
Total Cooling Load (kBtu/h)	29.8		32.0		29.2		32.0		32.0	30.8	3.0 ton
Room Air Flow (cfm)										
Foyer	75		103		83		103		103	91	
Dining	75		112		86		112		112	96	
Kitchen	89		80		89		76		89	84	
Breakfast	128		123		122		118		128	123	
Great Room	165		215		143		215		215	185	
Master Bedrm	138		178		121		178		178	154	
Master Bath	39		22		39		27		39	32	
Master Closet	13		13		13		13		13	13	
Laundry	14		14		14		14		14	14	
Game Rm	58		75		63		75		75	68	
Bedrm 2	75		61		75		55		75	67	
Hall, 2nd	21		21		21		21		21	21	
Bath 2	35		49		29		49		49	41	
Bedrm 3	77		57		77		63		77	69	
Bedrm 4	75		56		75		62		75	67	
Bedrm 4 Closet	10		10		10		10		10	10	

Main supply trunk (minimum cross section): 18x16

Supply Duct Diameter (in)	RHVAC program output				BSC Spec
Foyer	1-6	1-7	1-6	1-7	1-7
Dining	1-6	1-7	1-6	1-7	1-7
Kitchen	1-6	1-6	1-6	1-6	1-6
Breakfast	1-7	1-7	1-7	1-7	1-7
Great Room	2-6	2-7	1-8	2-7	2-7
Master Bedrm	1-8	2-6	1-7	2-6	2-6
Master Bath	1-4	1-4	1-4	1-4	1-4
Master Closet	1-4	1-4	1-4	1-4	1-4
Laundry	1-4	1-4	1-4	1-4	1-4
Game Rm	1-5	1-6	1-5	1-6	1-6
Bedrm 2	1-6	1-5	1-6	1-5	1-6
Hall, 2nd	1-4	1-4	1-4	1-4	1-4
Bath 2	1-4	1-5	1-4	1-5	1-5
Bedrm 3	1-6	1-5	1-6	1-5	1-6
Bedrm 4	1-6	1-5	1-6	1-5	1-6
Bedrm 4 Closet	1-4	1-4	1-4	1-4	1-4

Figure 2 System and duct sizing worksheet based on ACCA Manual J calculations

Air Transfer Area and Jump Ducts

In order to keep supply air from pressurizing closed rooms by more than 3 Pa, transfer grilles or jump ducts are installed to allow supply air to flow back to the central system return. The transfer areas and ducts are sized based on Equation 3. To calculate the

finished grille size, no more than 80% free area should be assumed, requiring that the transfer area be divided by at least 0.8.

$$A = \frac{\dot{Q}}{1.07\sqrt{3}} = \frac{\dot{Q}}{1.853} \qquad (3)$$

where: A = area in square inches

$\dot{Q}$ = air flow rate (ft^3/min)

As a general rule of our own, no room will have less than a 6" diameter jump duct, and master bedrooms usually will have between a 10" and 12" diameter jump duct, or equivalent transfer area. Master bedrooms are the hardest to transfer from since they have the largest air flow, including air flow to the master bath and walk-in closet.

Pulte Houston, Creek Bend, Transfer Area and Jump Duct sizing results

Plan 4244	Orientation of Front of House										
	N	NE	E	SE	S	SW	W	NW	max	avg	
Air Transfer Free Area (in^2)											
Foyer											
Dining											
Kitchen											
Breakfast											
Great Room											
Master Bedrm	87		99		77		102		102	91	
Master Bath											
Master Closet											
Laundry											
Game Rm	15		24		18		24		24	21	
Bedrm 2	24		17		24		14		24	20	
Hall, 2nd											
Bath 2											
Bedrm 3	26		15		26		18		26	21	
Bedrm 4	24		14		24		17		24	20	
Bedrm 4 Closet											
Jump Duct Diameter (in)											**BSC Spec**
Foyer											
Dining											
Kitchen											
Breakfast											
Great Room											
Master Bedrm	10		11		10		11		11	11	10
Master Bath											
Master Closet											
Laundry											
Game Rm	4		6		5		6		6	5	6
Bedrm 2	6		5		6		4		6	5	6
Hall, 2nd											
Bath 2											

Figure 3 Transfer area and jump duct sizing

Central Return Duct and Grille Sizing

Central return ducts should have at least one 90 degree bend between the air handler unit and the central return grille, and the air velocity at the face of the return grille should be less than 350 ft/min. This helps to reduce noise. To size the return grille, use Equation 3 and divide the result by 0.8 to account for about 80% free area which is normal for stamped return grilles.