



HVAC Sizing

A guide to properly sizing residential equipment

By IBS Advisors, LLC

San Antonio, TX



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I must confess: I am not a tin-bender, nor the son of a tin-bender. I am a building science consultant who was a 4th generation home builder before I took up this cause. While I have been frequently accused of maligning the HVAC contractor unfairly, in my defense 99% of the time they do not follow the code, published industry guidelines and industry best practices and instead deliberately choose to follow "rules of thumb" and "local accepted practice". Whose accepted practice? These practices I am going to expose certainly don't follow the ASHRAE guidelines, nor do they follow the guidelines put forth by the Air Conditioning Contractors Association (ACCA). Instead, a cult of mechanical voodoo has developed based upon outdated building practices and defended rigorously with "I've been doing this for 30 years!" (as if doing something wrong for a long period of time makes it right) and threats of creating discomfort for the client ("If you put that smaller unit in, I'm not going to guarantee that it is going to work. You will be uncomfortable because that little thing just can't handle the load!"). Unfortunately, most architects and builders know next to nothing about HVAC and are forced to rely upon the HVAC contractor to know his role; worse, they ASSUME that the fellow has actually done everything correctly!

Challenges in the Industry

In one Colorado study conducted by a utility company, they found that the air conditioning equipment was typically oversized between 143% and 322%. The same study also found that the heating equipment was oversized between 106% and 234%. Hank Rutkowski, PE, wrote the ACCA manual for performing load calculations. He has been quoted as saying that only 5% to 10% of the residential HVAC systems installed have ever had a load calculation performed and the contractors typically tell him "I've never been sued for installing too large a system." In a field study performed by Pacific Gas & Electric, they found that 53% of the cooling systems were oversized by a ton or more and Pacific Northwest National Laboratory found that a third of the systems were oversized by at least a ton!

Why would a system that is larger than necessary be a bad thing? Well, cooling systems that are larger than needed have a higher initial cost, are lousy at dehumidifying due to short cycling, create sudden temperature swings in the home, have lower efficiency ratings and higher operating costs, doesn't last as long as it should due to the increased wear and tear from the start-stop caused by short cycling, and ultimately creates discomfort for the homeowner. Combustion furnace heating systems that are oversized create additional issues like condensation in the flue pipe leading to rust and failure and corroded exchangers due to excessive airflow leading to condensation.

Unfortunately, most architects and builders believe that their HVAC contractor has properly performed an ACCA Manual J, 8th edition, load calculation to determine the heating and cooling load requirements, used ACCA Manual D to size the ductwork to deliver the right amount of conditioned air needed in each room, selected the equipment according to ACCA Manual S and has trained technicians who have properly installed the equipment and ductwork. The reality is that of the 5% to 10% of the homes that have Manual J load calculations performed, most of them are performed incorrectly and generally will back out to a local rule of thumb for square footage per ton (in my area it is 600 square feet per ton). This is an industry wide issue that I have personally witnessed from Virginia to Texas and Kentucky to Florida. I have been told by colleagues that it also exists everywhere else...

I spoke with an HVAC contractor in Texas who stated that he performed a 7th edition Manual J load calculation after he had already installed the equipment (using a square footage rule of thumb) in the first built model for a production builder. He did this on every new plan and never changed the size of the equipment to meet the "calculated" load and never updated the load calculation— not even after the builder upgraded to low-e windows, cellulose insulation with extensive airsealing, radiant barrier roof decking and joined the ENERGY STAR® program where every single home is inspected and tested for house and duct leakage by an independent 3rd party! The production builder (~ 400 homes per year) was understandably upset after I pointed out that they had been paying between \$2,000 and \$4,000 per house more than they needed to in oversized equipment. They had initially asked me to look at meeting the tax credit, but after this exposé they realized that they could reap far greater financial benefit by simply right-sizing the equipment— which is required by the building code!

When HVAC contractors perform a Manual J load calculation, they usually alter the outdoor design temperatures to create

greater temperature differences between the inside and outside; this creates greater heat losses and gains. They also like to use higher infiltration rates in the summer than winter so that they can boost the cooling load to deal with the extra dehumidification. They tend to model windows without internal shading devices or external overhangs, increase the size of the windows facing east and west, increase the number of people that permanently occupy the home (you want to be comfortable when you have your Christmas party!), increase the appliance loads on the home (honestly, I thought every floor had a kitchen!), model windows with lower performance than the installed windows, model lower insulation levels in attics, walls and floors and boost the grains of moisture to create greater humidity issues inside the home.

All Manual J load calculations should be performed using the latest edition (as of this writing, it is the 8th edition version 2). Manual J 8th edition has updated design temperatures and follows the ASHRAE standards for calculating the number of occupants (number of bedrooms + one) in addition to providing updated tables to reflect radiant barriers and low-e windows.

This is a chart I developed that shows the differences between the peak cooling load (only exceeded 1% of the time) calculated according to the 2005 ASHRAE Handbook of Fundamentals methodology and the cooling equipment installed by an HVAC contractor who relied upon "rules of thumb". As I dug further into the issue, I discovered that the reason the oversized equipment was installed was because the customers had been complaining to the HVAC contractor about being uncomfortable. The assumption on the part of the HVAC contractor was the equipment was too small to handle the load on the home. The reality was that the homeowners were uncomfortable because the distribution system (ductwork) was installed very poorly, resulting in the rooms not getting the airflow needed to condition the space. It wasn't the size of the equipment causing the problem, but the crappy ductwork! Naturally, the HVAC contractor proposed solving the problem with larger equipment which could potentially increase the airflow instead of fixing the duct installation– brilliant idea: spend an extra \$3,000 to fix a problem caused by a subcontractor not meeting the code requirements for duct installation!

Size of home (square feet)	Peak Design Cooling Load Range (Best & Worst Case Orientation)	Installed Equipment
1204	14.9 kBtuh – 15.1 kBtuh	30.0 kBtuh
1871	22.9 kBtuh – 25.5 kBtuh	42.0 kBtuh
2229	25.5 kBtuh – 27.3 kBtuh	42.0 kBtuh
2313	26.8 kBtuh – 29.0 kBtuh	36.0 kBtuh
2682	27.0 kBtuh – 29.6 kBtuh	48.0 kBtuh
2792	31.0 kBtuh – 31.5 kBtuh	60.0 kBtuh
3086	33.9 kBtuh – 37.0 kBtuh	66.0 kBtuh
3173	33.3 kBtuh – 34.4 kBtuh	60.0 kBtuh
3850	35.1 kBtuh – 37.2 kBtuh	78.0 kBtuh
4157	42.2 kBtuh – 45.6 kBtuh	72.0 kBtuh

The Solution to the Challenges

The solution is to ensure compliance with Manual J by hiring a knowledgeable person to review the load calculations supplied by the HVAC contractor or mechanical engineer. Do not rely upon the guy selling you equipment "by the ton" to tell you how much you need!

ACCA has published a list of Do's and Don'ts for Manual J and I have adapted them here:

1. Do not manipulate outdoor design temperatures.
2. Do not ignore internal shade devices– assume the home will have blinds
3. Do not ignore external overhangs

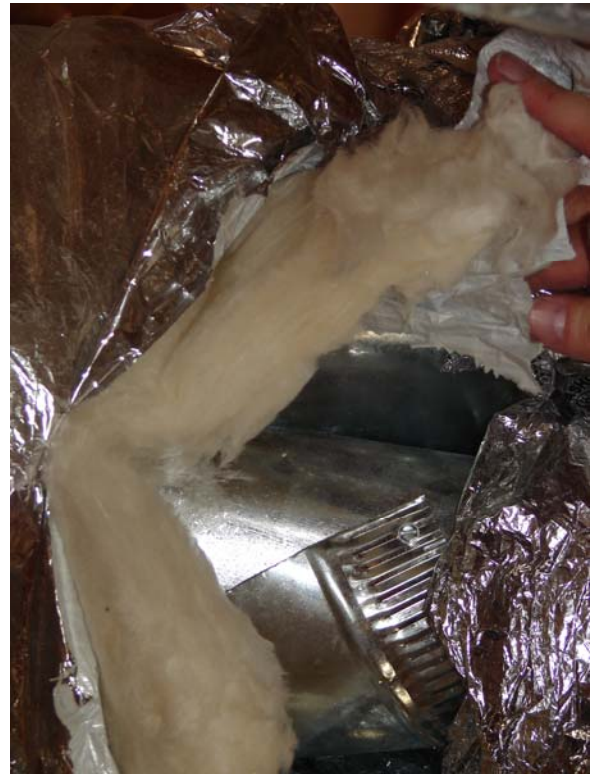
4. Do not include intermittent fans (bath and kitchen) as ventilation fans
5. Do not assume leaky ductwork and a leaky house
6. Do not assume code ventilation rates are the default infiltration rates
7. Do not assume worst case scenarios
8. Do verify all construction details prior to calculating Manual J
9. Do use the actual orientation
10. Do take full credit for insulation improvements to the building
11. Do take full credit for airsealing
12. Do follow the Manual J procedures for calculating ventilation and infiltration
13. Do use the outdoor design temperatures from Manual J or ASHRAE Handbook of Fundamentals, 2005
14. Do use the indoor design temperatures from the ASHRAE comfort chart
15. Do take full credit for sealed and insulated ductwork
16. Do match the duct location to the actual location as much as possible
17. Do match the duct system geometry as much as possible
18. Do take credit for documented window performance data
19. Do calculate the number of occupants as the number of bedrooms plus one
20. Do limit the number of appliances to those that would be on during peak load (usually around dinner time)
21. Do not design for record breaking weather conditions
22. Do not add safety factors into the calculation
23. Do not design for abnormally low or high outdoor temperatures or humidity
24. Do not reduce known insulation levels to be safe
25. Do not add internal loads for "entertaining groups of people"
26. Do not add internal loads for special events
27. Do not use "rules of thumb" based upon square footage

If Manual J is followed faithfully with any assumptions supported by building science and documented sources, the load calculation will be accurate without using any "safety factors" or fudging numbers because "that's the way I've done it for

30 years". At least this way, if a homeowner sues the HVAC contractor for sizing the system correctly it is completely defensible as opposed to trying to defend sizing based upon "rules of thumb".

There are many reasons why we should be concerned about oversizing cooling equipment beyond the extra cost to purchase and operate, increased potential for mold growth, poor comfort due to lousy mixing of the conditioned air with room air– it also increases the peak demand for utilities leading to larger regional issues. All because someone decided that 30 years of doing it wrong was better than following the International Residential Code, the International Mechanical Code, the International Energy Conservation Code and the ACCA procedures referenced by the code writing agencies.

What 30 Years of Experience Can Get You



References

Manual J, 8th edition version 2.0, Copyright © 2004 by Hank Rutkowski, PE, Air Conditioning Contractors of America, 2800 Shirlington Road, Suite 300, Arlington, VA 22206

“Bigger is Not Better: Sizing Air Conditioners Properly”, by John Proctor, Zinoviy Katsnelson, Brad Wilson, May/June 1995 issue of Home Energy Magazine

http://www.builtgreen.org/articles/0308_HVAC_sizing.htm

“Leakage Diagnostics, Sealant Longevity, Sizing and Technology Transfer in Residential Thermal Distribution Systems”, I. Walker, M. Sherman, M. Modera, J. Siegel, Environmental Energy Technologies Division, Energy Performance of Buildings Group, Lawrence Berkeley National Laboratory, Berkeley CA 94720

About the Author

A native of Southern California, Brett is a 4th generation carpenter & builder. Raised in a traditional construction background, he started to apply the principles of building science to the homes he built as the Construction Director for the Habitat for Humanity affiliate in Chattanooga, TN. As a result of those efforts, this affiliate was one of 16 affiliates worldwide that earned an energy efficiency award from Habitat for Humanity International at the 25th anniversary conference in Indianapolis in 2001.

Brett has extensive field experience performing HERS ratings, residential commissioning, energy audits, mold and moisture assessments, building envelope pressure tests, and duct system pressure tests in addition to his experience in construction management and techniques. He has been a licensed contractor in Tennessee and has over 15 years of experience in the residential construction industry, working in both land development and construction. He is now the Vice President and General Manager of IBS Advisors, LLC, specializing in the integration of building science, design and best construction practices.

Brett currently teaches many seminars and workshops on high performance home building, the International Energy Conservation Code, moisture control and homeowner education to groups as varied as the American Institute of Architecture to affordable housing providers. A former program manager at Southface, he was the point person for expanding the EarthCraft House program regionally into Alabama, South Carolina and Tennessee. He is a nationally certified Home Energy Ratings System (HERS) Rater in addition to being a Residential Energy Services Network (RESNET) certified HERS Rater Trainer and Quality Assurance Designee, the highest level of national certification available in the residential energy efficiency field. He also provides building science-based training to builder groups and utility companies, including teaching the Certified HERS Rater Course.

Brett has served on the Advanced Rater Task Force for RESNET, the Affordable Housing Task Force for LEED for Homes and has conducted workshops for the Building America Program (DOE) and State Energy Offices throughout the Southeast.

Brett is married, enjoys classical foil fencing with his wife and four sons and resides in Geronimo, Texas.

Contact information:
Brett Dillon
(210) 657-4427
bdillon@ibsadvisorsllc.com

