From: ECOHOME July-August 2011 Posted on: August 1, 2011

Right-Sized HVAC

Maximize performance with these five steps to right-size your HVAC systems from design through installation and testing.

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Credit: Ray Ng

You don't have to poke around very much to discover that most HVAC equipment sizing is still mostly a rule-of-thumb calculation based on outdated information and performance specs using high, medium, and low guesses. The assumptions that result have contributed to the unfortunate prevalence of oversized heating and cooling equipment connected to miles of ductwork installed in homes across the country. Accurate design, sizing, and installation of these systems needs to be improved—both to meet the performance levels of today's more efficient homes, but also the comfort and efficiency expectations of the people who live in them.

During my consultations with builders across the country I'll often ask them if they know how many BTUs/hour are in each ton of cooling, and most don't get it right. (It's 12,000 BTUs/ton by the way.) And while architects and builders might feel that this is the HVAC contractor's territory, knowing how to right-size a system to match the efficiency of your projects and assuring proper installation are critical in designing and building high-performance homes. Here are five steps that will help you achieve your goals.

1. Include functional specs for the insulation and sealing package.

Specify the correct level of insulation and the installed quality, not just the R-value printed on the bag or the depth you expect to blow in an attic. We have one chance for the life of the building to get this right. Specify high-density batts or better yet, use blow-in insulation to maximize the insulation in the walls; shoot for minimum R-22 in walls and R-50 in attics. Also consider using one of the new air-sealing systems that sprays a thin layer of foam to seal gaps between sheathing and framing in the stud and joist bays prior to installing cavity insulation. Using advanced framing techniques that reduce thermal bridging and increase actual insulated surface areas will also make a big difference, so let your HVAC contractors know this for their calculations as well. Finally, and maybe most importantly, verify the enclosure tightness of the building. It needs to be equivalent to .25cfm/ft2 of building surface area at 50 Pa. (There are various figures floating around today regarding the testing numbers but this is a good and reliable goal to reach.) Then make sure your system designer enters all these specs into his or her Manual J calculations. Manual J8 heat

loss and heat gain calculations are industry-accepted methods for determining the heating and cooling requirements for each room/zone in a home.

2. Use correct window U-value and SHGC specs in load calculations.

The correct U-value and solar heat gain coefficient (SHGC) on the windows must be included in the load calculations. Too often a default value is used and the wrong data will cause an increase in the A/C sizing. This can have a significant impact as 30% to 40% of the cooling load can be attributed to solar gain through the windows. Placement details like orientation, overhangs, and shading can also affect this information. I recommend U-values of .30 and SHGC of .30. We can fine-tune the last value to maximize south-side winter gain and also reduce the coefficient on western exposures to reduce summer heat. This is a discussion for another time but specifying the right glazing system will have lasting effects.

3. Design for ducts and distribution.

Design your projects with HVAC equipment and distribution system layout in mind from the beginning. High-efficiency HVAC equipment and ductwork should be located within the conditioned envelope of the home, and can be accommodated by using available framing systems like open-web floor trusses or pre-cut I-joists engineered for the duct opening cuts. The only thing that should go into the attic is more insulation. Right-sizing typically leads to a reduction in equipment size; a reduction in size equates to lower total airflows and thus reduces duct size. The improved thermal enclosure is significant and the access to equipment for future repairs, replacement, and filter changes makes this one the only choice. Create the Manual D & Manual S calculations off the original Manual J calculations, and the size of the system, the duct design, and airflows will be specified.

Performance testing is critical for right-sized HVAC systems, since they're operating within a narrower margin of error in terms of design calculations. Tight ducts and air-handling equipment are keys to overall performance, so make sure to run duct blaster tests to assure air leakage rates of 3% or less of gross air flow.

Credit: Harry Whitver

4. Seal ducts and air-handling equipment.

I often compare air handling and duct distribution systems with plumbing systems in terms of sealing them from leaking. We expect our plumbers to install tight systems, and we should do the same with our HVAC installers. The problem with leaking ducts is the damage they cause both in energy loss and potential indoor air quality issues. Seal ducts and air handlers to the same level required in plumbing, using mastic (no, not duct tape) at all joints,

elbows, connections, and terminations and require tested values not to exceed 3% of the gross air flow on the system at high speed using a duct blaster test at 25 Pa.

5. Test the system for performance.

Finally, as I just specified for the ducts, test the systems to perform as follows:

Duct tightness: Pressure test at 25 pascal.

Room to room pressure: Test the room to hallway pressure with a digital manometer, and specify that it should not exceed 2.5 Pa with the doors closed and the air handler running.

Delivered air flow: Proper air flow leaving HVAC registers determines the distance of throw away from the grille and will define the level of comfort you can expect. The right number comes from the Manual D design calculation and is verified using airflow measuring devices such as flow capture hoods, flow grids, and calibrated fans.

A/C system charge: All A/C systems must be charged with a refrigerant to allow them to do their job. National studies have shown a significant number of installed systems have the wrong charge and therefore operate well below the performance specified by the manufacturer. Be sure that every project has a final check of the system charge and that it is done according to industry standards.

Everything you put into tightening up your exterior shell including reducing air infiltration, increasing insulation levels, and installing high-performance windows should lead you to new specs for your HVAC systems. And if your current suppliers and trade partners aren't ready to respond to these new challenges, it may lead you to find new team members.

This list will help you design, specify, and install high-performance HVAC systems to match your efficiency design parameters and performance goals. Right-sizing your HVAC systems will not only help you achieve these goals, but could reduce your construction costs and may actually help you pay for other high-performance upgrades.

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