



Musings of an Energy Nerd

Contemplating residential energy use

SAVING ENERGY WITH MANUAL J AND MANUAL D

Experts tell builders that HVAC equipment and ducts should be designed according to Manual J and Manual D; the problem is, no one wants to do the calculations

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If you've been paying attention to energy-efficiency experts and green-building Web sites, you probably know that it's important to properly size your HVAC equipment. Most sources repeat the same advice: oversized furnaces and air conditioners cost too much, waste energy, and sometimes provide lower levels of comfort.

To avoid these problems, the first step is to insist that your HVAC contractor perform a Manual J calculation to determine the heat loss and heat gain for each room of your house under peak (worst-case) conditions. Then your contractor can specify equipment that meets Manual J requirements.

If you're building a new home, your contractor should design your duct system using Manual D. (Manual D depends on the room-by-room heat loss and heat gain numbers supplied by the Manual J calculations.) Sounds easy, right? Well, it isn't. In most areas of the country, it's very difficult to find a residential HVAC contractor who is willing to perform Manual J and Manual D calculations.

Helpful advice from your government

According to [the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy](#), "Homeowners should insist that contractors use a correct sizing calculation before signing a contract. This service is often offered at little or no cost to homeowners by ... conscientious heating and air conditioning contractors." Yeah, right.

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A smaller unit won't necessarily save energy. The stains on the concrete pad show that the new air conditioner has a smaller footprint than the oversized unit it replaced. Although most energy-efficiency experts strongly urge contractors to avoid oversizing HVAC equipment, researchers from the Florida Solar Energy Center have shown that right-sized air conditioners often use just as much energy as oversized equipment.

The government Web site goes on to advise, "When the contractors are finished, get a copy of their calculations, assumptions, and the computer printout or finished worksheet." Well, that's easy for *you* to say. But just see how easy it is to get that paperwork from Bob once his Do-It-Right HVAC Service has finished installing your new air conditioner.

Calculation — Part 2

Calculating Cooling Loads

When Do I Need to Perform a Load Calculation?

We Are the 99% — AND the 1%

Air Conditioner Basics

IBACOS: Accurate Heating and Cooling Load Calculations

IBACOS: HVAC Equipment Sizing

Easy enough for an 8th grader to do it — Quick, find me an 8th grader

Manual J and Manual D are calculation worksheets published by the Air Conditioning Contractors of America (ACCA). For many years, these worksheets have been the standard methods for calculating residential heat loss, heat gain, and duct sizes.

Manual J and Manual D calculations are no longer performed with a pencil and paper; contractors now use software programs. Hank Rutkowski, the mechanical engineer who wrote (and continues to update) Manual J, explained to me how Manual J calculations are performed: "To bridge the gap between the complexity of the paper manual and the contractor

you have to have software. It was never our intention that people do the calculations by hand. The manual serves as a guide to computer programmers. The key is the software, which takes the complexity and makes it simple enough for an eighth grader to use. ... The contractor never has to deal with the equations."

The best-known Manual J software programs are [Elite RHVAC](#), [Wrightsoft Right-J8](#), [Adtek AccuLoads](#), and [EnergyGauge](#).

Software programs for Manual D duct design include [Elite DuctSize](#) and [Wrightsoft Right-D](#).

A Manual J heat loss and heat gain calculation considers most of the factors that affect HVAC equipment sizing, including the climate; the size, shape and orientation of the house; the home's air leakage rate; the amount of insulation installed; the window areas, window orientations, and glazing specifications; the type of lighting and major home appliances; and the number and even the age of the occupants. For the calculations to be meaningful, information on all of these factors must be correctly entered into the software program.

Manual J and Manual D calculations are required by most building codes

The 2006 International Residential Code requires (in section M1401.2) that "Heating and cooling equipment shall be sized based on building loads calculated in accordance with ACCA Manual J or other approved heating and cooling calculation methodologies."

Furthermore, IRC section M1601.1 requires that "Duct systems serving heating, cooling and ventilation equipment shall be fabricated in accordance with the provisions of this section and ACCA Manual D or other approved methods."

There's some wiggle room in the code, of course; individual inspectors can theoretically approve "heating and cooling calculation methodologies" other than Manual J. But the intent of the code is to outlaw rule-of-thumb sizing — for example, "one ton of cooling per 400 square feet."

Where can I find a contractor to do it?

As with many code provisions, the requirement for Manual J and Manual D calculations is widely ignored and rarely enforced.

Most residential furnaces, boilers, and air conditioners are still sized by rules of thumb instead of careful calculations. As a result, almost all of the HVAC equipment installed in U.S. homes is oversized. Dozens of studies have confirmed that the degree of oversizing typically ranges from

30% to 200%.

Builders and homeowners who ask HVAC contractors about Manual J and Manual D calculations are usually met by a blank stare. One homeowner posting under the name Tom21769 posted the following anecdote on the [HVAC-Talk Web forum](#): "I've had a bunch of contractors out, most of them sales reps but a couple with technical/repair backgrounds, and not a single one has brought up the subject of Manual J. In one case, when I asked about getting one, the guy did not know what I was talking about. They all seem to assume that if a 2-ton system is in here now, that's what the replacement needs to be."

On [his GBA blog](#), Carl Seville recently reported, that it "is difficult to obtain ... an accurate HVAC Manual J calculation. It seems that few HVAC contractors understand how to prepare an accurate report, often oversizing systems out of habit rather than designing them for the actual house loads. Also, while the reports are supposed to be delivered before the equipment is installed, they rarely are, and mistakes are usually identified well past the time to make any corrections."

Another GBA blogger, [Michael Chandler](#), reported, "When I have asked my HVAC contractor what it would cost to add Manual D, he responds that a \$12,000 system with J alone would be \$15,000 with D. That may be his way of saying that he doesn't know how to do it, but the fact remains that this is a very common situation with residential HVAC contractors who can barely implement Manual J."

[Elsewhere](#), Michael Chandler wrote that his local planning board was "still not even enforcing the Manual J requirement which results in inefficient, oversized air conditioners and attendant humidity and mold problems. Even though reps of the local HBA pointed out the benefit of requiring Manual J, the county is still not requiring proof that a Manual J has been done to award a certificate of occupancy."

On [another GBA page](#), energy consultant Allison Bailes wrote, "HVAC contractors, at least here in the Southeast, don't often do Manual J load calculations at all. They mostly use rules of thumb based on square footage (e.g., 500 square feet per ton of AC capacity). When they take the time to enter data and run a Manual J, they usually do it incorrectly."

Even when they do the calculations, the results are usually wrong

In his posted comment, Bailes raised an interesting point: the problem of "garbage in, garbage out" (GIGO) Manual J calculations. Several energy experts have commented on the GIGO problem, including [John Proctor](#), [Hank Rutkowski](#), and [Allison Bailes](#).

Hank Rutkowski, the mechanical engineer who wrote the original Manual J document, was recently interviewed for a profile posted on [the Green Building Talk Web site](#). The piece notes, "Rutkowski estimates that only 10% of heating and cooling equipment sizing decisions are based on some type of Manual J calculation and that less than 1% of the jobs are based on an aggressive implementation of the recommended design procedures."

Rutkowski explains the GIGO problem this way: "Manual J is a good tool if you use it aggressively. Follow the rules and it will give you a reasonable margin of safety. But the average contractor says, 'Better safe than sorry,' so he fudges here and there. He adds 5 to 10 degrees to the summer and winter design temperatures, calls the building 'average' instead of 'tight' and doesn't take credit for shading by interior blinds and drapes. Then when he finally comes up with a load

number for sizing, he throws in an extra half-ton of AC just for the heck of it.”

For a high-performance home, sizing by Manual J may still result in oversizing

Several years ago, I had a conversation with building scientist Joe Lstiburek about air conditioners installed in Building America homes in Las Vegas. “HVAC designers are committed to the institutional oversizing of air conditioning equipment,” Lstiburek told me. “The average system is sized at 150% to 200% of the requirements of Manual J. They oversize because they don’t know what they will get for a building envelope, and to compensate for duct leakage and inappropriate refrigerant charge. If you size according to Manual J, there is already a fudge factor built in. But most designers then add another fudge factor.”

According to Lstiburek, their experience proved the high-performance Building America homes in Las Vegas could have had HVAC systems sized at about 60% of Manual J. To be conservative, his team recommended installing systems sized at 80% of Manual J.

Does oversizing matter?

There are strong arguments against routine oversizing of HVAC equipment. The best argument is simple: oversized equipment usually costs more than right-sized equipment.

Oversized equipment suffers from short cycling. For example, an oversized furnace brings a home up to temperature quickly, and then shuts off. A few minutes later, it comes on again, only to shut off quickly. Many homeowners find the see-saw sound of a short-cycling furnace to be annoying.

When air conditioners short cycle, the units don't run long enough to achieve much dehumidification — at least in theory. (During the first few minutes of operation, an air conditioner cools a house. But not enough moisture has collected on the cold coil or on the pan below for any water to have actually gone down the drain. When the air conditioner turns off, all of the moisture in the pan and on the coil just re-evaporates.)

The conventional wisdom may be wrong, however

Increasing evidence shows that energy experts have exaggerated the negative effects of equipment oversizing, however. Studies have confirmed that oversized furnaces don't use any more energy than right-sized furnaces. Moreover, newer modulating or two-speed furnaces operate efficiently under part-load conditions, solving any possible problems from furnace oversizing.

Although there are ample reasons to believe that oversized air conditioners are less effective than right-sized equipment at dehumidification, **at least one field study** was unable to measure any performance improvements or energy savings after replacing an existing oversized air conditioner with a new right-sized unit.

The bottom line

The main reason to choose right-sized equipment is to avoid paying too much money for equipment you don't need. A Manual J calculation will ensure you don't spend more than necessary for your furnace, boiler, or air conditioner.

Moreover, a Manual J calculation will provide room-by-room heat loss and heat-gain information that is essential to good duct design. Without good duct design, you're running the risk of comfort complaints.

Last week's blog: "**Sealing Ducts: What's Better, Tape or Mastic?**"

TAGS: **AIR CONDITIONER SIZING, EQUIPMENT SIZING, FURNACE SIZING, MANUAL D, MANUAL J, OVERSIZED, OVERSIZING, RIGHT SIZING, FURNACES, HEATING, COOLING, HVAC**

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