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**Eliminating Mix-and-match SEER**
↳ Page 12

**The Green Impact of Efficient Duct Design**
↳ Page 17

# KEEPING *Cooling Towers* IN TIP-TOP CONDITION

↳ Page 22



17 **The Green Impact of Efficient Duct Design**
Correctly sizing and installing ductwork can make an HVAC system and the system owner "green" in more ways than one.

**Finding the Skills for Tomorrow's Jobs—Today**
↳ Page 36

# THE GREEN IMPACT OF EFFICIENT DUCT DESIGN

BY CHRIS VAN RITE

## PROPERLY SIZING AND INSTALLING DUCTWORK CAN MAKE AN HVAC SYSTEM AND THE SYSTEM OWNER "GREEN" IN MORE WAYS THAN ONE.

The "green revolution" is more than just stickers, slogans and marketing; indeed, with so many products claiming to be "green," it is hard to know just what green really means.

The intent of the green movement is to encourage the use of energy-efficient products and practices that also have a positive—or at least neutral—impact on the environment. This concept has expanded to include an assessment of the amount of energy used to create those products and deliver them to the construction site.

Energy efficiency has a direct link with the environment, because for every kilowatt hour of electricity homes and buildings consume, there is a measurable amount of pollution emitted into the atmosphere. Electric power plants that use fossil fuels constitute the largest source of air pollution in the U.S. According to data from the Energy Information Administration's "Emissions from Energy Consumption at Conventional Power Plants and Combined-Heat-and-Power Plants," in 2007, electric power plants produced approximately 2.5 billion tons of carbon dioxide, nine million tons of sulfur dioxide and 3.6 million tons of nitrogen oxides. This is why the U.S. Department of Energy and the Environmental Protection Agency are exerting so much influence on energy-efficient building codes and incentive programs.

Every aspect of a construction project is under closer scrutiny today, especially the HVAC system, which is often the single largest energy-consuming component in a building. Whether the HVAC industry embraces the green building approach or not, building codes; federal, state and city legislation; and incentive programs are pushing the industry

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**<< Solid metal ductwork allows for the efficient movement of air and helps equipment operate at peak efficiency. Hybrid duct systems (inset) combine the efficiency of metal duct with the convenience and noise attenuation of 5 ft of flexible duct at the end of the branch run to connect to the register box.**

in that direction—and there are real opportunities for those who find ways to capitalize on it.

## The great waste

Technology and federal mandates have resulted in the development of higher-efficiency HVAC equipment (and accompanying higher SEER ratings), but poor installations cause equipment to work harder and run longer—often reducing energy efficiency to levels below the federal minimum standards. If this high-efficiency equipment is not properly installed, it simply will not perform as designed or as advertised.

Proper duct design is critical to HVAC system performance, yet for far too many HVAC contractors, designing, sizing and installing ductwork has become almost an afterthought. Pressure to cut costs and inexperience on the part of some contractors has eroded the overall quality of system installations, especially with the duct system. While a bad duct system may sufficiently deliver air to condition the home or office, it increases static pressure losses—which lowers the efficiency of the system and cheats the customer out of the performance and the value they paid for.

Proctor Engineering Group reports that, "different energy studies have been conducted on air flow in the past several years. Each study found that, on average, 70% of all home air conditioners have inadequate air flow. The average home air conditioner's air flow is 20% below the manufacturer's recommendation." (See the chart on pg. 19 for more information.)

## Making it better

When it comes to proper ductwork design and installation, there are a wide range of factors that can impact the system. Here are five common mistakes that affect HVAC system performance—and some suggested best practices on how to fix those problems.

**Using load averages instead of running load calculations**—If a contractor uses load averages such as tons or CFM/sq ft instead of running an accurate load calculation for each structure, they may oversize or undersize equipment due to the orientation of the structure, the efficiency of the building envelope and the effects of (or lack of) natural or constructed shade. In addition, load averaging may not factor in heating and cooling requirements for various climate zones. Hot and humid climates have very different load requirements than cooler and dryer climates, but many of the "shoot from the hip" load formulas ignore these differences.

Many cities are now requiring an ACCA "Manual J" or other approved load calculation to be submitted as a part of the permit-application process. Whether or not cities require them, accurate load calculations should always be run to guarantee the HVAC system is designed properly.

**Selecting duct materials based on price rather than performance**—Flexible duct is the least expensive duct material to purchase and install, as well as the least efficient for moving air when compared to metal duct or fiberglass duct board.

Even when properly installed, flexible duct has twice the static pressure loss of round metal duct. Duct board triangles and similar "splitter boxes" are inexpensive, versatile and allow for infinite installation options in the field. However, the use of these fittings instead of traditional wyes increases static pressure losses and encourages "design on the fly" installations.

The Consortium for Energy Efficiency reports that a "quality installation can reduce energy consumption by as much as 35% and peak demand by as much as 25%." This can save the average homeowner $300/year or more. These savings will easily pay for more-efficient system components. Contractors should sell their customers on the efficiency value of higher-quality materials and installations.

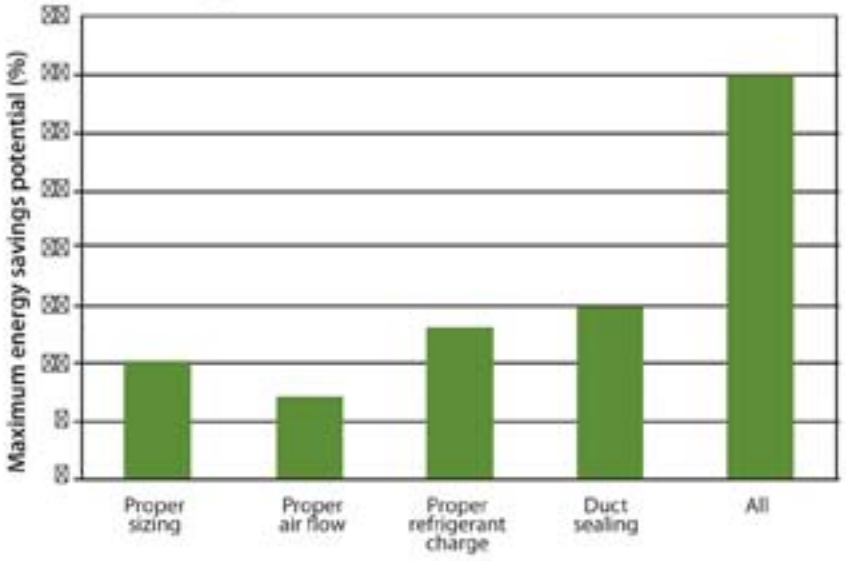
**Inadequately sizing ducts**—Unfortunately, duct sizing today often means supplying 7–10-in. ducts to big rooms; 4–6-in. ducts to smaller rooms; and 14–18-in. ducts for returns—with size selections made based on instinct, availability or price. These practices fail to address the real load requirements for different rooms and further perpetuate the notion that duct sizing is not important.

When flexible duct is used, the designer must take into account that the flex duct is not likely to perform as the design manuals predict due to variations in the installation. To make matters worse, the friction loss tables, duct calculators and software for sizing flexible duct are based on testing with the flex duct stretched 96% in a straight line and supported on a flat surface. Since flex is rarely installed this way, there is little correlation with this design data and the actual performance of flex ducts as they are commonly installed.

Contractors should take airflow and pressure-loss measurements to confirm that ducts are delivering air as designed, and make appropriate changes to materials, size and installation.

**Failing to ensure that installations are done properly**—Design performance and installed performance can be similar only if ducts are installed as designed. This sounds redundant to say, but framing and other obstructions can cause unavoidable deviations from the design. These changes often reduce airflow due to additional turns, crimping restrictions and additional length. While some of these changes may be

## Potential energy savings through energy-efficient HVAC installation




Source: *National Savings Potential From Addressing Residential HVAC Installation Problems (1999)* by Chris Neme, Vermont Energy Investment Corporation; John Proctor, Proctor Engineering Group; and Steve Nadel, American Council for an Energy-Efficient Economy.

unavoidable, it is imperative that proper duct installation practices be maintained on every duct run from the plenum to the register box.

The most efficient ducts are straight, smooth and short. Installing ducts in any other way introduces friction losses that are not accounted for by many design practices. Flexible ducts should be stretched tight; failure to do so will compress the core and dramatically increases static pressure losses.

**Failing to design and install to maximize system performance**—Contractors often design duct systems based on habits or common practices of the region, which may include limited material and size selections, and regionally popular materials. These practices evolve over time and too often ignore fundamental design requirements for maximizing efficient operation.

The design focus should always be on performance. If a contractor fails to make every effort to maximize system performance, they are breaking a trust with the customer. Proper sizing and installation of the duct system is essential to maximizing system performance. That is what the customer paid for and rightfully expects.

## Incentives create opportunity

The U.S. Congress has approved income-tax credits to encourage the installation and use of energy-efficient products and practices. Many electric power companies and city energy offices also are offering programs to fund and encourage higher-efficiency new construction projects and retrofits.

These programs vary greatly, but many provide funding for qualified improvements that easily cover the cost of upgrades. Duct-improvement measures usually qualify for these programs. In addition to these existing initiatives, a great deal of federal funding from the American Recovery and Reinvestment Act of 2009 is earmarked for energy-efficiency programs. *[Editor's Note: See the April 2009 RSES Journal Industry News item "Stimulus bill stirs the HVACR industry" for more information.]*

One thing is certain, while there is more funding than ever to help develop and promote energy-efficient HVAC equipment and practices, the federal government also is going to increase pressure and incentives for states to adopt more energy-efficient building requirements. HVAC contractors who focus on, and specialize in, these products and practices will find themselves in the main stream of the next economic boom. Conversely, those who fail to recognize these opportunities may find that their competition has moved on to "greener pastures."

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### ASHRAE PROVIDES FLEX DUCT GUIDELINES

ASHRAE has published a series of Advanced Energy Design Guides, intended to raise building efficiency 30% above the level established with ASHRAE Standard 90.1. Each of these books recommends that supply and return ducts be designed with a static pressure drop of no more than 0.08 in./100 ft.

Flexible duct runs are recommended to be:

- Restricted to connecting branch ducts to diffusers or VAV boxes to diffusers;
- Limited to 5 ft or less (fully stretched length); and
- Installed with no more than 15% compression.

These design guides can be downloaded for free at ASHRAE's Web site. The ASHRAE 2009 Fundamentals Handbook also suggests flexible duct runs be installed 95% stretched with no turns or bends.