rsesjournal.com

APRIL 2009 $5.95

RSES

RSES Journal

HEATING, VENTILATION, AIR CONDITIONING AND REFRIGERATION

In Air-conditioning Systems, CORRECT SIZE DOES MATTER

PAGE 12

Sizing up a GEOTHERMAL SYSTEM

While geothermal HVAC systems have to account for loop size and other issues related to heat-transfer, properly sizing equipment and related components is critical to crafting an energy-efficient comfort solution.

BY SONNY HAMPTON

▲Geothermal loop sizes and underground pipe arrangements—which can be horizontal, vertical or in a pond—are important elements contractors must consider, but application-specific equipment sizing also is vital to the installation process.

Energy efficiency is critical for today's homeowners and facility managers considering new HVAC systems—both for retrofitting aging, inefficient systems and selecting equipment for new construction projects. And the tax credits and other incentives included in the recently announced federal stimulus package only further encourage consumers and business owners to consider more energy-efficient upgrades.

But even the most energy-efficient equipment cannot deliver the anticipated savings—as much as 70% in some cases for geothermal heating and cooling comfort systems—if the equipment is not properly sized. And unfortunately, efficiency and energy savings are not the only things sacrificed by improper sizing—so are comfort and cost.

Sizing impacts efficiency

Improperly sizing geothermal equipment can create many system-efficiency problems. An undersized system, for example, runs longer than necessary because, quite simply, the equipment cannot deliver the desired amount of conditioned air. Longer run times for both the heat pump and the auxiliary heat that supplements the system sacrifice efficiency. Plus, because the system is unable to deliver the required heating and cooling, occupant comfort is compromised, leaving occupants too warm in the summer and too cold in the winter.

Oftentimes, A/C and heating systems are oversized, as some contractors follow a "better safe than sorry/bigger is better" approach to the sizing process. However, occupants are frequently sorry, because a too-big system is *not* better. In fact, oversized equipment is likely to cycle on and off frequently, reducing system efficiency. In the summer months, these short run times prevent equipment from running long enough to remove the air's latent humidity, creating a cool but clammy environment.

Some pieces of equipment also have a fixed run time, operating for a set time period before shutting off. In these instances, if the equipment is oversized, it can produce temperature swings that overshoot the thermostat's setpoint and an environment that, depending on the time of year, is either too hot or too cold.

In areas where heating demands outpace cooling requirements, contractors often select two-stage equipment and size the equipment to meet the extra demands of the heating load. However this runs the risk of oversizing the cooling load in the process. Fortunately, two-stage heat pumps operate at low speed approximately 70% of the time and may, in fact, never have to run at full capacity. Similarly, in climates where higher temperatures are the norm and cooling loads are high, contractors may size equipment to meet increased cooling demands, even though that may mean oversizing the heating load.

In either case, this slight oversizing of one operating mode to satisfy the demands of the opposite mode may actually benefit the homeowner. That is because the selection of two-stage equipment to meet higher heating or cooling demands ensures more cost-effective and efficient heating or cooling in the low-speed stage, which makes for a more comfortable, less noisy environment.

That aforementioned noise is another concern with large, oversized equipment. Equipment and/or blowers that move large quantities of air through the ductwork can generate higher noise levels that are distracting to homeowners and building occupants.

Load calculation is key

Preventing problems associated with incorrectly sized equipment begins with a heat-gain/-loss calculation. In fact, whether the HVAC service professional is installing a geothermal or a traditional heating and cooling system, determining a structure's heat- gain/-loss is perhaps the single-most important step they can take to ensure efficient systems operation and occupant comfort.

The Air Conditioning Contractors of America's (ACCA) "Manual J Residential Load Calculation" is used by most service professionals to determine the heat-gain/-loss. Using software or manual solutions based on "Manual J," contractors survey and record data that impact the structure's heat-gain/heat-loss, including: insulation values; the number, placement, and type of windows, doors and trees around the structure; weather stripping; primary building materials; exposure to sunlight; overhangs; items offering wind shielding; number of fireplaces and flues; attic accesses; number of occupants; equipment in the structure that generates heat—including appliances, computers, lighting and media systems; roof and siding color; and size of the actual living space.

The resulting survey is most useful when calculated on a room-by-room basis. That way, contractors also can properly size ductwork to ensure adequate air flow is delivered to each room. Conducting a load calculation based on heat-gain/heat-loss also means that HVAC service professionals are following other important guidelines that ensure proper equipment sizing. Such a survey means they consider every home individually—regardless of similar appearances—and avoid the temptation to size equipment based solely on a structure's square footage or the sometimes limited information on house plans.

Retrofit requirements

Contractors dealing with retrofits should not assume the existing HVAC equipment was properly sized when it was originally installed. In fact, it is not unusual to find older equipment that is oversized for the structure. The original installer may not have calculated heat-gain/heat-loss, or perhaps the building is now a tighter structure with less heat loss—especially in older homes that have been improved with new windows, doors and insulation—making it a candidate for downsized equipment.

When retrofitting, the ductwork of a conventional HVAC system can be reused in a geothermal installation—provided it is clean, serviceable and insulated at the appropriate places. The ductwork, however, should be properly sized so it can handle the amount of air the geothermal heat pump will generate.

As with an ordinary HVAC system, the cfm delivery of a geothermal HVAC system's equipment determines the sizing of its corresponding ductwork. The range for ductwork in a geothermal system is typically 360–400 cfm/ton. It should be noted that in a structure with hot water circulating through pipes under the floor (in-floor radiant heating) as a means to maintain comfort, those pipes also support the geothermal system.

▲**Properly sizing a geothermal system is beneficial from an energy-efficiency standpoint, but it also can help simplify the design and installation process—making it easier for technicians entering a mechanical room to troubleshoot problems or make adjustments to system components and equipment.**

▲**In geothermal systems, the pipe joining process utilizes heat fusion to create a joint stronger than the actual pipe. Underground pipes are fused with heat to ensure that foreign items do not enter the pipe, which could contaminate the system or damage equipment.**

Baseboard heating also can be incorporated into a geothermal system, although an additional hot-water source may be required to increase water temperatures from the 130°F temperature typically produced by a geothermal heat pump to the 160°F–200°F range required by a baseboard distribution system.

Loop size matters too

Perhaps the biggest difference between sizing a geothermal system and an ordinary HVAC system relates to the ground or earth loop. This system of small-diameter, high-density polyethylene underground pipes—installed horizontally, vertically or in a pond—carries an environmentally friendly solution that transfers heat energy from the ground or from the structure, depending on whether the system is in the heating or cooling mode.

While geothermal equipment is sized primarily to the

▲The soil consistency and climate of a geothermal system's installation plays a significant role in both how the system is designed and the size of the loop that will be necessary to transfer heat.

load calculation, a geothermal loop is sized to the equipment, the type of soil and the climate. The larger the tonnage of the geothermal system's equipment, the larger the loop is required to accommodate that equipment. Loops may be longer, deeper and farther apart to meet increased cooling or heating demands and transfer more heat to or from the ground.

Soil type is extremely important when sizing a loop, because the thermal conductivity—the rate at which soil can absorb energy—varies. Rock, for example, is very dense and therefore holds a significant amount of heat or transfer heat as necessary. Clay and loam—a soil that contains about 60% sand, 20% silt (particles 0.002–0.02 mm in diameter) and 20% clay—also work well, as long as they are damp or saturated. Sandy soil absorbs the least amount of energy. In general, the drier the ground, the larger the loop is required to support a geothermal system.

Because soil type is so important to sizing a geothermal system, most software designed to help contractors in the sizing process asks for the type of soil at installation sites, along with the average depth of the loop and the city where the loop will be installed. With this information, the software can determine the average earth temperature for a particular area, the thermal conductivity of the soil, and ultimately, the loop size required to reject heat to or extract heat from the ground.

Selecting proper controls also is important to geothermal system selection and sizing. Thermostats continue to get smarter and provide more and better diagnostics for both the consumer and the technician. Depending on system size, they also allow for zoning, which translates to increased efficiency and better comfort control throughout a structure.

Tools make sizing easier

In many cases, the procedures and tools for sizing a geothermal system are identical to sizing an ordinary HVAC system, beginning with the heat-gain/-loss calculation and "Manual J." Additional support, particularly with loop sizing, is available through manufacturers' training programs, literature and software. For example, WaterFurnace International Inc. offers contractors a geothermal design- and energy-analysis program that utilizes ACCA's "Manual J" and ASHRAE standards for input loads and climate tables of nearly 300 cities worldwide to generate designs and proposals for any residential or light-commercial project.

[*Editor's Note: The National Re-Renewable Energy Laboratory—which is a national laboratory of the U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy—has a list of geothermal technology analysis models and tools that can help assist with learning more about the sizing process. Most of these can be applied on a global, regional, local or even project basis. Visit www.nrel.gov/analysis, select "Technology Analysis" under "Models and Tools" in the left column, and then "Geothermal Analysis" to learn more.*]

By taking advantage of these tools and training opportunities, contractors can position themselves to meet increased demands for energy-efficient geothermal systems, fueled in part by the recently passed federal stimulus package. The American Recovery and Reinvestment Act of 2009 offers a one-time tax credit of 30% of the total investment for residential ground-loop or groundwater geothermal heat pump installations.

The time and effort required to size a geothermal system are not significantly different from conventional HVAC systems, and the benefits are similar as well, which include: an easier installation with fewer upfront costs; fewer callbacks once the system is up and running; and a more energy-efficient, comfortable system.

A properly sized geothermal system can provide additional benefits as it draws from a free, renewable supply of solar energy; achieves efficiency ratings up to five times higher than ordinary HVAC systems; ensures more even distribution of heating and cooling; improves indoor air quality; lowers maintenance costs—with an average system life span of 24 years; and reduces the carbon footprint, since the system burns no fossil fuels.

The final results of taking the proper steps when sizing a geothermal system: satisfied customers who will seek the same contractor's services in the future and refer new customers for years to come.◆

Sonny Hampton is the Training Manager for WaterFurnace International Inc. A licensed plumber in Illinois, he has more than 40 years experience in the HVAC industry and is certified in geothermal design. For more information, call 217-538-2110 or send an e-mail to sonny.hampton@waterfurnace.com.