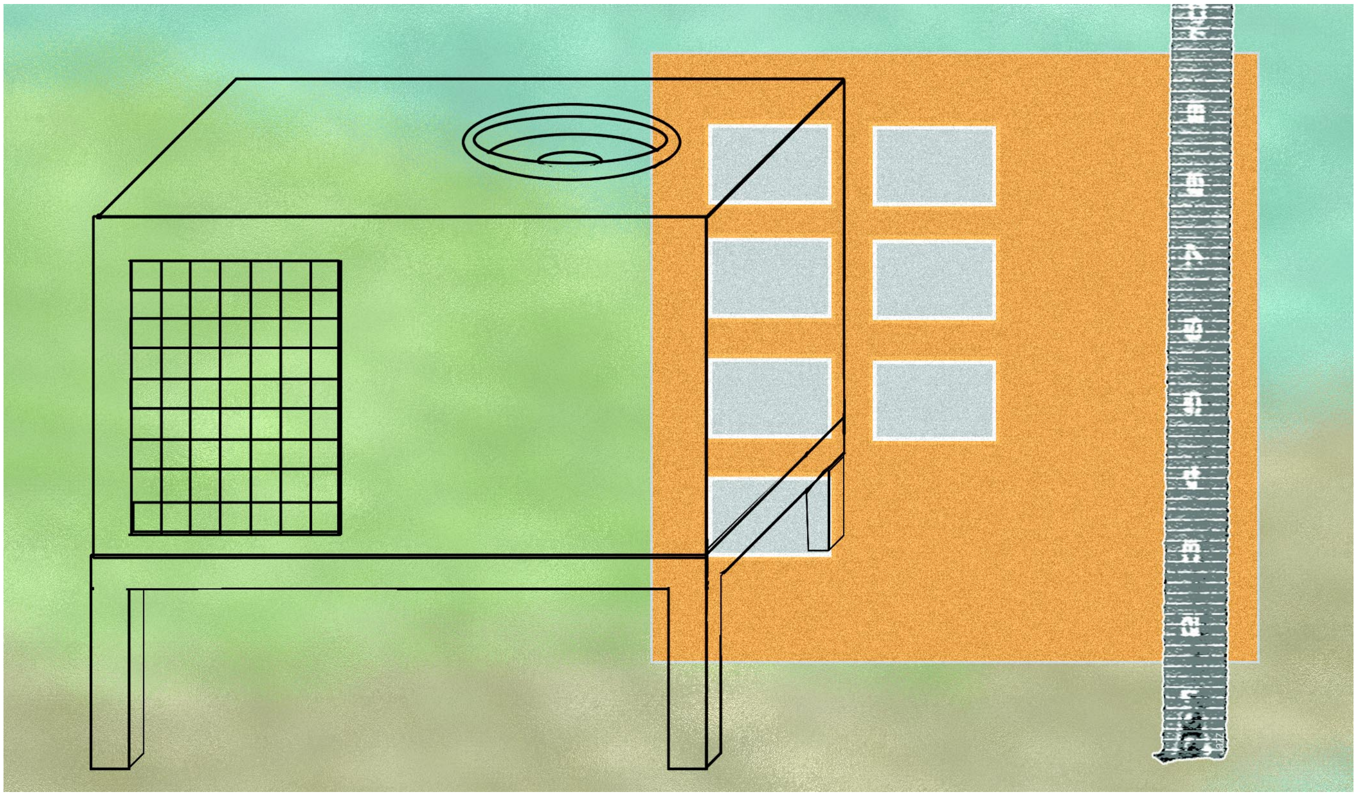

How to Properly Size Unitary Equipment

By Glenn C. Hourahan, P.E., Member ASHRAE

Oversized air-conditioning systems significantly degrade the ability of unitary HVAC equipment to control humidity within residential and commercial buildings. Additionally, oversizing causes many other problems such as large temperature differences between rooms, occupant discomfort, higher installed cost and excessive part-load operation (see sidebar on Page 16).

Reasons for designers/contractors to routinely oversize HVAC equipment include not performing load calculations, performing load calculations incorrectly, and attempting to avoid customer complaints. However, to properly size HVAC equipment, a rigorous heat gain/heat loss procedure must be observed. This article summarizes key steps in performing such a procedure.

Step 1: Establish Building Design and Criteria Requirements

Before undertaking a load calculation, ascertain the type of HVAC systems (i.e., ducted vs. ductless equipment, gas-fired furnaces vs. electric heat pumps, etc.) that are compatible with the building and the building's application. This includes determining space requirements and occupant needs. Appearance issues, architectural design concerns, and space constraints also influence system selection, as well as how the mechanical equipment responds to design and building requirements. The overall building budget and system budget also impact the type of system, zoning, and capabilities of the equip-

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ment to be selected. The fuel types available to the site, in addition to their relative costs, also have an impact.

Step 2: Determine the Design Loads

Determining heat loss/heat gain loads at design conditions requires examination of several parameters.

Building Construction Parameters

It is critical that building construction parameters be evaluated carefully, and that assumptions on the related building details are verified carefully. Examples of such deliberations include: building envelope, insulation type/level, glass type and shading, solar orientation, and duct tightness/location.

Design Conditions

Outdoor design conditions should be the 1% cooling dry-bulb design point for the specific geographic location of the building. The indoor design conditions should be based on customer needs and requirements. As a default, designers should observe the following nominal indoor design conditions:

Winter Heating Design Point: 70°F (21°C) at 30% relative humidity.

Summer Cooling Design Point: 75°F (24°C) at 50% relative humidity.

Full Load vs. Part Load

In performing the load analysis, it is important to pay attention to the sensible (i.e., temperature related) and latent loads (i.e., moisture related). It needs to be recognized that the load calculation is based on the peak-load conditions (sensible + latent). For summer cooling, this generally occurs on a sunny, hot day, and the peak sensible load occurs at the peak dry-bulb condition. However, what happens in the evening when the sun sets? What if it is raining? It is reasonable to expect some summer hours when the outdoor condition may be in the low 80°Fs and relative humidity is 100% (it's raining!).

Since the design methodology results in equipment sized for peak dry-bulb temperature (the hot, sunny afternoon), the air conditioner has excess capacity when operating at non-peak, part load duty (the other 99% of the time). Constant volume unitary equipment, in being oversized for a part-load condition, easily satisfies the thermostat and cycles off long before moisture removal can be affected. Cycling results in a warmer coil temperature with less latent capacity than a colder coil. Hence, just when latent removal capability may be needed most, it is least available. The tradeoff is whether it is preferable to be a little warm on the hottest days, or maintain setpoint on the design day, thereby providing poorer humidity control almost all of the rest of the time.

Step 3: Do Not Add Safety Factors

Once a load calculation has been determined, and the sensible and latent loads established, it is important not to ruin the good work by arbitrarily adding safety factors. Routinely adding "just-in-case" safety factors of 25% to 100% is unacceptable for most unitary applications. The practice results in equipment cycling (and hence a warmer average coil temperature), and may result in too much airflow (again increasing the coil temperature and decreasing latent capacity). Additional ways to ruin an otherwise good load determination include:

• **Overly conservative assumptions on the building construction details.** Purposely using "loose" or "conservative" design criteria to increase the calculated cooling requirement is unnecessary and counterproductive for obtaining proper loads.

• **Failure to observe room and building diversity factors.** The required capacity is not necessarily the sum of the peak individual room loads. It must be observed that buildings with large levels of solar glass load — especially if these windows are predominantly on one side of the structure — will have rooms with large loads that peak at different times than other rooms.

• **Upsizing equipment in the belief that bigger is better.** This is a problem with customers who think buying a larger unit for nearly the same money is a good value. Designers need to explain the benefits of using properly sized equipment.

Step 4: Verifying System Capacities

In verifying capacities and making the

Effects of Oversizing

- Marginal part load temperature control
- Large temperature differences between rooms
- Degraded humidity control
- Drafts and noise
- Occupant discomfort/dissatisfaction
- Larger ducts installed
- Increased electrical circuit sizing
- Excessive part load operation
- Frequent cycling (loading/unloading)
- Shorter equipment life
- Nuisance service calls
- Higher installed costs
- Increased operating expense
- Increased installed load on the public utility system
- Increased potential for mold growth
- Potential to contribute to asthma and other respiratory conditions

Reasons for Oversizing

- Load determination was not made
  - Prior experience is used to "guess" the load
  - Simple replacement of "like" for "like":
    - Assumes that the original installation was correct
    - Ignores whether building functions have changed
    - Ignores building upgrades (lighting, insulation, etc.)
  - Use of obsolete and inadequate "rules of thumb"
- Incorrect observance of procedures
  - Mistakes in the load calculation
  - Overly conservative assumptions on building attributes
  - Use of safety factors
  - Designers compensate for air distribution problems by oversizing equipment
- Safeguarding callbacks
  - Designers seek to minimize occupant complaints on days that exceed design conditions

final equipment selection, it is essential to observe all manufacturers' sizing, selection, and application guidelines. As previously noted, be sure that the equipment can meet the sensible and latent cooling requirements without being oversized. For controlling moisture within the building, it is crucial that designers verify that the selected equipment has the capability to handle the latent load at full load operation (peak dry bulb conditions) *and* part load operation (peak wet-bulb conditions).

Step 5: Considerations if Equipment Cannot Satisfy Latent Requirements

If the selected unitary equipment is unable to satisfy the full-load and/or part-load latent requirements, equipment manufacturers offer innovative solutions for modulating latent capacity:

• Modified control strategies that engage the cooling equipment based on humidistat demand. However, humidistat control is likely to require reheat to prevent overcooling in the conditioned space. Other control sequences can permit the evaporator to operate at a lower temperature.

• Optimized equipment using multi-speed/variable-speed indoor fan units enable lower supply air temperatures. Reduced airflow increases opportunities to remove moisture from the airstream.

• Hybrid equipment that uses wrap-around heat pipes or air-to-air heat exchangers. The intent is to reheat the dry supply air leaving the dehumidifying coil with heat recovered from the air entering the coil. This approach allows the cooling coil to wring out as much moisture as possible from the preconditioned air.

For humid applications, or where a high level of humidity control is needed, designers should consider independently controlling temperature and humidity:

• Whole building dehumidification equipment (perhaps interconnected to the primary fan and using the same duct system as the air-conditioning system) can independently control moisture loads.

• Dedicated outdoor air systems can better reduce the moisture loads that arise due to the introduction of warm, moist air for ventilation requirements since the outdoor air is preconditioned before mixing with the indoor return air.

Both approaches eliminate a major part of moisture load, and allow the primary coil to do a better job of sensible cooling.

Conclusion

Correct sizing and selection of unitary equipment, appropriately controlled, are important steps to maintain proper humidity levels. This requires configuring the HVAC system to meet sensible and latent loads, not only at the design conditions (full load), but also over a broad range of off-design conditions (part loads).

Subsequent steps for controlling building humidity levels include ensuring the selected building systems (HVAC equipment, ductwork, envelope, etc.) are properly installed, commissioned, maintained, and serviced over the building's life.