An approved code change to the 2009 International Residential Code (IRC) clarifies an existing requirement for sizing HVAC equipment: “Heating and cooling equipment shall be sized in accordance with ACCA Manual S based on building loads calculated in accordance with ACCA Manual J or other approved heating and cooling calculation methodologies” (emphasis added).

Air Conditioning Contractors of America (ACCA) Manual S, Residential Heating and Cooling Equipment Selection, provides clear instructions for interpreting and applying original equipment manufacturer (OEM) expanded performance data to select equipment that meets application requirements (heating, sensible cooling or latent cooling) for the applied design conditions used to calculate loads with ACCA Manual J, Residential Load Calculation. It also provides the methodology for identifying the blower airflow design value, in cubic feet per minute (cfm), which is subsequently used per IRC Section 1601.1 with ACCA Manual D, Residential Duct Systems, to calculate duct sizing.

In addition, Manual S sets equipment sizing limits, as summarized in Table 1. These sizing limits ensure
that equipment capacities meet the minimum needs of occupants while preventing the problems associated with oversizing.1

### How to Apply Manual S

#### Heating, Part One

Manual J heating load calculations produce values, in British thermal units per hour (BTU/h), for selecting HVAC equipment.

Take for example a home that requires a minimum of 56,000 Btu/h of heat to maintain an indoor temperature of 70°F when the outdoor temperature drops in the winter. Based on the sizing limitations (100%–140% of heating load), the furnace must have a capacity between 56,000 Btu/h and 78,400 Btu/h (140% x 56,000). Per the manufacturer's product data given in Figure 1, XYZ model FR 80-036—with an output capacity of 64,000 Btu/h—meets the requirement. Model FR 80-024 does not meet the minimum design temperature, while FR 125-036 has too much output capacity.

#### Cooling

The cooling loads given in Manual J for the example home are: total cooling = 30,000 Btu/h, sensible cooling = 22,000 Btu/h and latent cooling = 8,000 Btu/h. Based on the Manual S sizing limitations (100%—115% of the cooling load), the air conditioner must have a capacity between 30,000 Btu/h and 34,500 Btu/h (115% x 30,000).

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1. Heat pumps in a cooling dominant climate are allowed to be 115% of the cooling level.
2. Heat pumps in a heating dominant climate are allowed to be 125% of the cooling level.

*The size of the cooling equipment must be based on the same temperature and humidity conditions that were used to calculate the Manual J loads.
When selecting cooling equipment, it is necessary to know the design conditions used to calculate the cooling load. Unlike heating equipment, cooling equipment OEM data offers a range of performance at different outdoor and indoor conditions. The design conditions for the example home are given in Table 3.

Figures 2 and 3 provide OEM expanded performance data for two air conditioners: a 2.5-ton capacity model and a 3.0-ton capacity model. Manufacturers may present this data in a different format, but all should include airflow, entering air wet-bulb temperature, outdoor temperature, and cooling capacities (usually, total and sensible capacities). Note that a slightly different approach is employed when using Manual S to verify cooling equipment selection than to select the equipment. Verification begins by considering the outdoor air temperature and indoor wet-bulb temperature.

The 2.5-ton air conditioner seems like a natural choice for a home with a 30,000 Btu/h cooling load because a 2.5-ton unit has a nominal capacity of 30,000 Btu/h. However, the OEM data for XYZ model AC-30 reveals that the unit does not meet the Manual S total cooling capacity requirement at the design 95°F outdoor temperature and 63°F entering wet-bulb temperature. In contrast, according to the OEM data, XYZ model AC-36 has enough total cooling capacity (31,510 Btu/h) without exceeding the 115-percent limit (34,500 Btu/h). The system’s sensible cooling capacity (23,000 Btu/h) also meets the sensible cooling load (22,000 Btu/h) and the latent capacity (total capacity – sensible capacity = latent capacity 8,510 Btu/h) meets the latent load (8,000 Btu/h).

Another critical design element is the volume of air that must flow over the indoor air conditioner coil to achieve the required cooling capacities. The furnace manufacturer will provide blower performance data indicating the air flow that the unit can deliver at different levels of resistance. Referring to the fan performance data given in Figure 4 for XYZ model FR 80-036 (1,035 cfm at 0.60 inches water column [iwc], interpolated to 1,050 cfm at 0.58 iwc), the furnace can deliver the airflow required per ACCA Manual D.

### Sensible and Latent Loads

There are two aspects to the consideration of cooling load: sensible and latent loads. The sensible load is the heat that is measured by a thermometer or a thermostat. This is the “dry” heat one consciously feels. The latent load is the heat associated with airborne moisture as measured by a hygrometer or a humidistat.

When you enter a home whose thermostat shows a cool temperature but which has high latent heat—or relative humidity—the initial feeling is comfort. But as your body adjusts to the temperature you begin to feel sticky, clammy and uncomfortable. You may even feel warm again. This is why two homes with the same thermostat setting can feel very different.

### Figure 1. Furnace product data for XYZ 3.0-ton air conditioners.
design temperature rise range of $35^\circ F$–$65^\circ F$.

Air temperature rise through the furnace depends on the rate of flow through the heat exchanger. If the air flow is outside of the temperature rise range, the equipment may cycle off at safety limits, suffer damage or possibly even create an unsafe condition. Incorrect air flow can cause too much temperature rise (slow-moving air may allow the heat exchanger to become too hot, which can result in warping or cracking of the metal heat exchanger) or too little temperature rise (fast-moving air may cause condensation in the metal heat exchanger, which can result in the production of an acid that can harm or penetrate the heat exchanger).
An air flow rate is acceptable if it yields a temperature rise within the range prescribed by the equipment manufacturer. In our example, 1,050 cfm equates to an acceptable (35°F–65°F) furnace temperature rise of approximately 55°F:

\[
\Delta T = \frac{\text{Btu/h}}{\text{CFM} \times 1.1 \times ACF}
\]

55.4°F = 64,000 / (1,050 x 1.1 x 1.0)

where:

- \( \Delta T \) = temperature difference in the air between the inlet and outlet of the furnace or cooling coil
- \( \text{Btu/h} \) = thermal output capacity of the furnace or cooling system
- \( \text{CFM} \) = volume of air, in cubic feet per minute, moved through the furnace by the blower assembly
- 1.1 = a physical air constant (derived from the laws of physics)
- ACF = altitude correction factor; 1.0 at sea level

**Conclusion**

This article serves to demonstrate the value of the adopted code revision in ensuring that appropriate load calculations are used as the basis for HVAC equipment selection: one more way that First Preventers can protect the health and safety of building occupants across the country.

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**Notes**

1. Oversizing can lead to health issues associated with excessive humidity; higher costs for equipment and installation labor and materials; greater energy consumption; and more wear and tear on equipment.
2. This considers both the temperature and moisture content of the air.
3. When the blower moves 1,050 cfm over the XYZ model AC-36 indoor air conditioner coil, it delivers the required cooling capacity. If the airflow value changes, the equipment capacity and performance also change.
4. In this case, the actual furnace output capacity of 64,000 Btu/h is used, not the 56,000 Btu/h design capacity from the load calculation.

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