Residential Heating and Cooling Loads

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OVERVIEW

• Brief systems engineering introduction
• Discussion of heating and cooling loads by way of examining the system sizing process.

SYSTEM ENGINEERING TRADE-OFFS

• Better Envelopes
  – Allow for reduced cooling system size
  – Decrease energy consumption
  – Increase occupant comfort
  – Make overall performance more predictable
  – Improve the more permanent features of a home which has longer-term sustainability benefits to society
SYSTEM ENGINEERING TRADE-OFFS

- Reduced cooling system size
  - Helps pay for a better envelope
  - Avoids cooling system short-cycling
    - which improves moisture removal
    - allows the system to operate at higher average efficiency

- More efficient systems
  - Are most cost effective when the load is high
    - this is in circular conflict with our premise to first reduce loads through improved envelopes
  - High efficiency cooling systems generally have a higher evaporator coil temperature which reduces moisture removal
    - some of this can be altered with effective control of ECM air handlers

Do this before you start

- Builder must commit to these
  1. Building enclosure leakage $\leq 0.35$ cfm\(50/ft^2\) enclosure surface area
  2. Ducts inside conditioned space, or duct leakage $\leq 5\%$ to outside
  3. Glazing U-value and SHGC $\leq 0.35$
  4. Proper return air provision to assure $< 3$ Pa pressure differential between rooms to common area

High performance building envelopes deserve high performance comfort conditioning systems.

Especially for refrigerant based cooling systems, proper sizing and startup procedures are critical.
1. Computer software adhering to ACCA Manual J version 8 will be used to calculate loads for cooling and heating systems.
   - RHVAC from Elite Software (www.elitesoft.com)
   - Right-J from Wrightsoft (www.wrightsoft.com)

2. Duct gain and loss:
   - Best to locate entire air distribution system inside conditioned space, duct gain and loss=zero
   - If not in conditioned space, then air seal with mastic, insulate to R-8 with metalized insulation wrap;
   - Duct gain and loss will be calculated by the software, however, divide the total conditioned floor area used to calculate the duct surface area by two.

3. One appliance will be equal to 600 Btu/h. Put one appliance in the laundry, and two appliances (1200 Btu/h) in the kitchen. If an auxiliary entertainment area (or equivalent space) exists, then put one appliance there.
   - Use Energy Star appliances and electronics, put less heat back into the space

<table>
<thead>
<tr>
<th>Room supply cfm</th>
<th>Transfer grille height required for listed width in inches</th>
<th>Jump Duct Diameter</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>10 (in) 12 (in) 14 (in)</td>
<td></td>
</tr>
<tr>
<td>&lt;=150</td>
<td>8 8 8</td>
<td>8</td>
</tr>
<tr>
<td>&gt;100 and &lt;=125</td>
<td>8 6 8</td>
<td>8</td>
</tr>
<tr>
<td>&gt;125 and &lt;=150</td>
<td>10 8 8</td>
<td>10</td>
</tr>
<tr>
<td>&gt;150 and &lt;=175</td>
<td>12 10 8</td>
<td>10</td>
</tr>
<tr>
<td>&gt;175 and &lt;=225</td>
<td>14 12 10</td>
<td>12</td>
</tr>
</tbody>
</table>
SYSTEM SIZING SPECIFICATION

4. Gain from people will be set at 300 Btu/h sensible and 300 Btu/h latent, per person.
   – Could be as low as 230 sensible and 200 latent, but not worth arguing over

5. People will be placed around the house as follows:

   **Basic house**
   Total people in house = the number of bedrooms plus 1

<table>
<thead>
<tr>
<th># bedrooms</th>
<th>Total people</th>
<th>People in master bedroom</th>
<th>People in family and/or living room</th>
<th>People in kitchen</th>
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</thead>
<tbody>
<tr>
<td>2</td>
<td>3</td>
<td>1</td>
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<td>4</td>
<td>5</td>
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</table>

6a. Infiltration
   – For houses with tested building enclosure leakage below 0.35 cfm50/ft² CFA set at 0.2 ach summer and 0.3 ach winter.
   – For houses with tested building enclosure leakage below 0.25 cfm50/ft² CFA set at 0.1 ach summer and 0.1 ach winter.

6b. Ventilation
   – Set at ASHRAE 62.2 rate both summer and winter.
     \[ 7.5 (N_{o} + 1) + 0.01(A_{out}) \]
     – 50 cfm for 2000 ft² 3 bedroom house
7. Glazing U-value and SHGC must be entered according to the NFRC label for the exact glass being installed (get written confirmation from the purchasing manager).

U-value and SHGC of less than 0.35 is good

Interior shading will be selected as:
Drapes-medium, 50% drawn, no insect or external shade screens, ground reflectance equal to 0.20 except ground reflectance equal to 0.32 for glass adjacent to concrete areas such as a patio.

Exception: French doors, entry door side glass, and multi-story open-space windows such as used in foyers (not including transom windows) shall have “None” as internal and external shade. Bathroom windows shall have obscured or block glass.

8. Outdoor design conditions:
– Heating: set at the Manual J standard value for the closest climate
– Cooling: set at the ASHRAE 0.4% design for cooling. Indoor cooling design conditions will be set at 75 F drybulb and 63 F wetbulb (50% RH).

10. The building design cooling load shall be calculated for the worst case elevation option at the solar orientation that produces the highest heat gain.

11. Equipment selection, Heating
– Meet design heating load with no more than 50 F temperature rise (supply air – room air). Good target is 110 to 115 F supply air, or 40 to 45 F temperature rise.
### Heating Temperature Rise

<table>
<thead>
<tr>
<th>Equipment matched</th>
<th>30°F</th>
<th>45°F</th>
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<tbody>
<tr>
<td>Indoor and outdoor coils</td>
<td>84, 54, 45</td>
<td>110, 73, 63</td>
</tr>
<tr>
<td>The equipment will be selected to meet the design sensible load at the outdoor and indoor design conditions (not ARI standard conditions of 95 outdoor and 80/67 indoor).</td>
<td></td>
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</tr>
<tr>
<td>ARI rating conditions may be very different than actual operating conditions. Extended performance capacity data is important for the designer to properly size the equipment and not resort to common over-sizing habits to compensate for lack of information.</td>
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<td></td>
</tr>
<tr>
<td>Apply 1/2 of the unused latent capacity back to sensible capacity as given by ACCA Manual S.</td>
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</table>

### System Sizing Specification

- **11. Equipment selection, Cooling**
  - Indoor and outdoor coils will be ARI matched
  - The equipment will be selected to meet the design sensible load at the outdoor and indoor design conditions (not ARI standard conditions of 95 outdoor and 80/67 indoor).
  - ARI rating conditions may be very different than actual operating conditions. Extended performance capacity data is important for the designer to properly size the equipment and not resort to common over-sizing habits to compensate for lack of information.
  - Apply 1/2 of the unused latent capacity back to sensible capacity as given by ACCA Manual S.
### Building Science Consortium

**58STA/STX, 4-Way Multipoise Induced Combustion Gas Furnace**

Input Capacities: 45,000 thru 155,000 Btuh

#### Product Data

<table>
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<tr>
<th>UNIT SIZE</th>
<th>SPEED</th>
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<th>0.4</th>
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### 24ABA4

**CHARGING SUBCOOLING (TXV—TYPE EXPANSION DEVICE)**

**UNIT SIZE—SERIES** | **REQUIRED SUBCOOLING (F)**
---|---
18—30 | 10
24—30 | 11
30—30 | 8
36—30 | 10
42—30 | 12
48—30 | 9
60—30 | 9

**Notes from Carrier Statement:**

- Sensible capacities as shown in Detailed Cooling Capacities are based on 86 F 72/71 entering air at the outdoor coil. For sensible capacities as at other than 90 F 72/71, enter 86 F 80% data (24V 404W 10,000 Btu/hr) at indoor coil air at each stage below 86 F 72/71, or and 90% data (24V 424W 10,000 Btu/hr) half way 100 F 404W (80% of air capacity at 90 F 72/71).
## Table 2: Target Temperature Split (Return Dry-Bulb – Supply Dry-Bulb)

<table>
<thead>
<tr>
<th>Return Air Dry-Bulb (°F)</th>
<th>Return Air Wet-Bulb (°F)</th>
<th>Temperature Split</th>
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<tbody>
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Source: California Energy Commission report 2001