Technical Note
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Saving the Planet One Building at a Time

Derivation of 400 CFM per Ton Rule

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We show the approximate rule of thumb of 400 CFM/Ton is reasonable.

The sensible heat Qs is

$$q_S = CFM\,\frac{ft^3}{\min}\times 60\frac{\min}{hr}\times 0.24\frac{btu}{lb\cdot °F}\times\frac{1}{13.34}\frac{lb}{ft^3}\times\left(T_2-T_1\right)°F = \frac{60\times 0.24}{13.34}CFM\times\Delta T \qquad (1)$$
$$= 1.079\cdot CFM\cdot\Delta T$$

Where the CFM is related to the sensible heat by

$$CFM = \frac{q_{s(btu/hr)}}{1.079\cdot\Delta T\left(°F\right)} \qquad (2)$$

The latent heat is

$$q_L = CFM\,\frac{ft^3}{\min}\times 60\frac{\min}{hr}\times\frac{1}{13.34}\frac{lb}{ft^3}\times\frac{1}{7{,}000}\frac{lb}{grain}\times 1{,}050\frac{btu}{lb}\times\left(G_2-G_1\right)\frac{grains}{lb} \qquad (3)$$
$$= \frac{60\times 1{,}050}{13.34\times 7{,}000}\,CFM\cdot\Delta G = 0.68\,CFM\cdot\Delta G$$

Where the CFM is related to the latent heat by

$$CFM = \frac{q_L\left(btu/lb\right)}{0.68\Delta G\left(grain/lb\right)}$$

The room is to be maintained at 78° F DB, 50% RH. Assuming that the air would be introduced into the room at about 58° F which is 20 degrees below room temperature then ΔT=20°. The total heat capacity is 12,000 BTU/hr. = 1 Ton and the sensible heat ratio SHR = 75%.

Conditions:

$$\Delta T = 20°F$$
$$SHR = 0.75$$
$$q_T = 12{,}000\left(btu/hr\right) \qquad (4)$$
$$q_S = SHR\times q_T\left(btu/hr\right) = 9{,}000\left(btu/hr\right)$$
$$q_L = \left(1-SHR\right)\times q_T\left(btu/hr\right) = 3{,}000\left(btu/hr\right)$$

So, for a SHR of 75% there is 417 CFM/Ton ≈ 400 CFM/Ton.

$$CFM = q_s\div\left(1.079\,\Delta T\right) = 9{,}000\div\left(1.079\times 20\right) = 417\approx 400 \qquad Q.E.D \qquad (5)$$

Note: If the temperature difference we choose is much larger than 20 degrees, we should have difficulty mixing the cold supply air with room air in a way that would avoid drafts. We might also approach a condition where moisture would freeze on the coil surface. On the other hand, if it were much less than 20 degrees, ducts, fans, etc. would become larger and more costly to run due to the increased CFM.