# Technical Bulletin

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## *COMPARING AIR COOLER RATINGS – Part 1*

**Background**

Manufacturers of air coolers publish cooling capacities based on differing assumptions and rating methods. It is important for refrigeration design professionals to understand these different rating methods and to apply them appropriately. In extreme cases, air coolers can be grossly undersized even though nominal catalog ratings appear to satisfy the calculated refrigeration load. The smaller size and lower first cost of air coolers which are inadvertently undersized due to misunderstood or misapplied ratings are seductively attractive to contractors and end users, however, the price difference will ultimately be more than paid for by the unsuspecting end user whose undersized air coolers cause lower-than-expected operating suction temperatures with associated increased energy consumption and loss of refrigerating capacity.

**Temperature Difference**

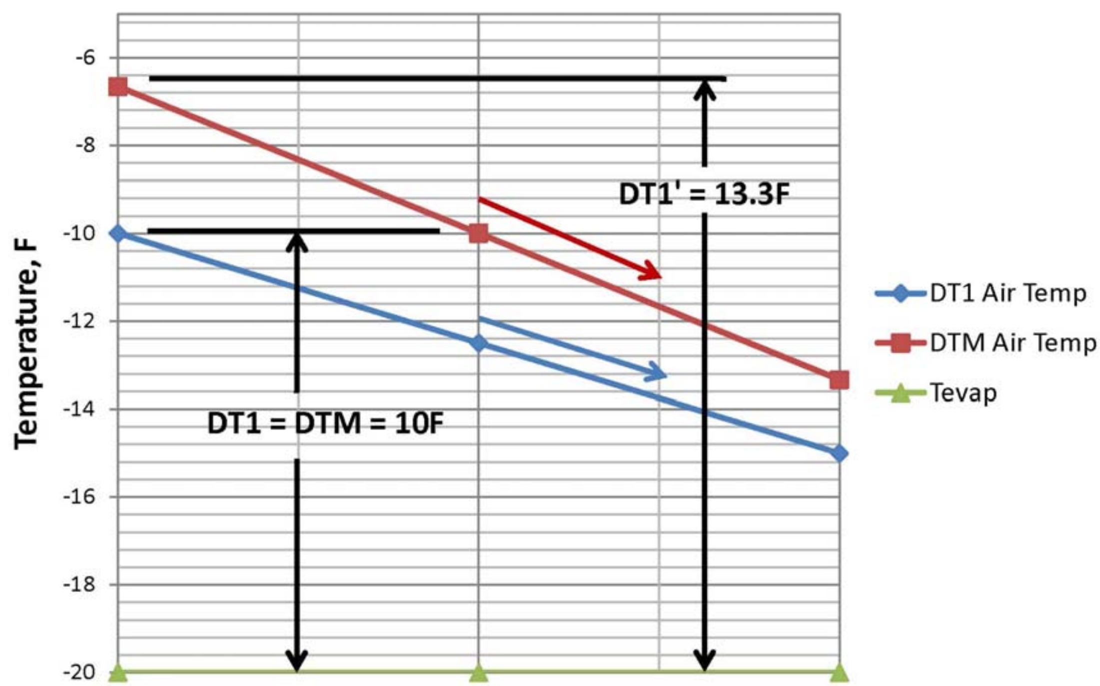
In a room being refrigerated by air cooling evaporators, the change in the temperature of the air (reduction) as it passes through the evaporator coils will equal the change in the temperature of the air (increase) as it circulates throughout the room. This means that in a well designed cold room, the air temperature gradient found in the room will be roughly equal to, and will be determined in large part by the air temperature change in the evaporator coils.

The initial temperature difference (entering air temperature minus the evaporating temperature) is referred to as “DT1” (or “TD”) in the refrigeration industry. Sensible cooling capacity can be considered to be proportional to DT1. Hence, if evaporator coil sensible capacity is known for a given DT1, then capacity at a new initial temperature difference, DT1’, can be found simply by multiplying the original capacity by the ratio DT1’/DT1. For example, a refrigeration air cooler has a rating of 10 TR at a DT1 of 10F. The capacity of the same cooler operating with a new DT1 of 12F will be very close to 10 x 12/10 = 10 x 1.2 = 12 TR.

**Average Room Temperature and DTM Ratings**

For the specific case where; 1) air coolers are ceiling mounted (i.e. operate at the warmest location in the room), and 2) the system control temperature sensor is mounted at a location where it will sense the ***average*** room temperature (i.e. at the midpoint elevation in the room), some manufacturers of air coolers publish ratings based on ***mean*** (average room) temperature difference. This average temperature difference is termed “DTM”. DTM ratings for the same air cooler will always be higher than DT1 ratings since the effective initial temperature difference seen by the evaporator coil is higher by approximately ½ of the air temperature change. Figure 1 below illustrates the same evaporator operating with DT1 = DTM = 10F. It is easy to see from the figure that the DTM capacity rating will be much higher than the DT1 rating since the DTM definition of temperature difference results in a much larger ***initial*** temperature difference (DT1’ in the figure). It is interesting how the same evaporator can produce more cooling capacity simply by redefining “temperature difference”!

**FIGURE 1**
**DT1 vs DTM Air Temperatures**




DT1 ratings used with actual anticipated air on temperature will always result in accurate ratings and correct air cooler selections. This method for air cooler selection is conservative and recommended whenever air on temperature to the coil is less than the maximum found in the room or process.

**Converting DT1 to DTM Air Cooler Ratings**

The equation below can be used to convert from known a DT1 air cooler rating to a new DTM rating for the same cooler.

$$\dot{q}_{DTM} = \frac{\dot{q}_{DT1} \cdot \frac{DTM}{DT1}}{\left(1 - \frac{\dot{q}_{DT1}}{2 \cdot 60 \cdot C_p \cdot \rho \cdot \dot{V} \cdot DT1}\right)} \qquad \text{(IP)}$$

where:

$\dot{q}_{DTM}$ = capacity at mean (room)temperature difference, Btu/h
$\dot{q}_{DT1}$ = capacity at initial (air on) temperature difference, Btu/h
DT1 = initial temperature difference = Air On Temp – Evap Temp, F
DTM = mean (room) temperature difference = Ave Room Temp – Evap Temp, F
$C_p$ = air specific heat, Btu/lbm F
$\rho$ = air density, lbm/ft3
$\dot{V}$ = actual volumetric air flow rate, ft3/min

Example:

An air cooler has a DT1 rating of 120,000 Btu/h at DT1 = 10F and -10F air on temperature. The cooler has a published airflow rating of 18,850 CFM. Assume the coil is operating with average air density = 0.0883 lbm/ft3, and average air specific heat = 0.24 Btu/lbm F. Note this is the same cooler shown in Figure 1 above. Find the DTM rating for the same cooler with DTM = 10F.

From the above equation:

$$\dot{q}_{DTM} = \frac{120{,}000 \cdot \frac{10}{10}}{\left(1 - \frac{120{,}000}{2 \cdot 60 \cdot 0.24 \cdot 0.0883 \cdot 18{,}850 \cdot 10}\right)} = 160{,}050\ Btu/h$$

DTM ratings are significantly higher than DT1 ratings for the same air cooler operating under the same conditions. In the case of the example, the DTM rating is +33% greater than the DT1 rating. Put another way, an air cooler selected with a 10F DTM rating of 160,050 Btu/h must actually operate with a DT1 (“TD”) of 13.3F to deliver the “rated” capacity of 160,050 Btu/h!

**Impact of Latent Load (SHR) On Air Cooler Ratings**

The ratio of the sensible cooling load divided by the total cooling load is called the Sensible Heat Ratio (SHR).

$$SHR = \frac{Sensible\ Cooling\ Load}{Sensible\ Cooling\ Load + Latent\ Cooling\ Load}$$

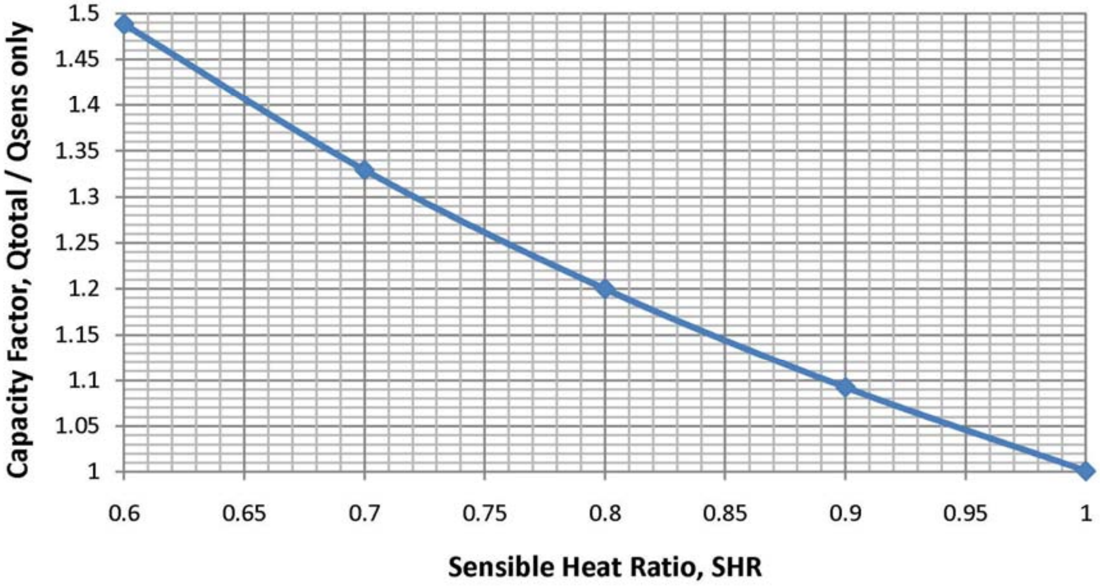
Relative humidity of the refrigerated space can be predicted by plotting the air process line on a psychrometric chart with a slope equal to the calculated SHR. Table 1 below shows typical Sensible Heat Ratios for various air temperatures at 95% air on relative humidity.

**TABLE 1**
**SHR FOR 95% RH AIR ON AND DT1 = 10F AT VARIOUS TEMPERATURES**

| Room Temperature, F (C) | SHR |
|---|---|
| 45 (7.2) | 0.55 |
| 32 (0) | 0.66 |
| 10 (-12.2) | 0.83 |
| 0 (-17.8) | 0.89 |
| -10 (-23.3) | 0.93 |
| -30 (-34.4) | 0.97 |

The equations governing total cooling capacity (sensible + latent) for an evaporator are complex and are beyond the scope of this bulletin. Suffice it to say, total cooling capacity is a function of the fin surface effectiveness and SHR. The increase in capacity due to the addition of latent cooling as a function of SHR for an ammonia refrigeration evaporator coil having typical fin spacings and geometry with DT1 = 10F can be estimated from Figure 2 below.

FIGURE 2
Total Cooling Capacity Factor vs SHR




Some manufacturers of air coolers publish ratings at air on relative humidity as high as 95%. Ratings published on this basis include both sensible and latent cooling with a resultant SHR as shown in Table 1.

Air cooler ratings which include latent cooling will always appear higher (in some cases significantly higher) than all sensible ratings as is apparent from Figure 2. Care must be taken, therefore, to correctly predict the cooling load SHR and the resulting relative humidity in the refrigerated space. It should be noted that misapplication of air cooler ratings based on high room relative humidity (i.e. 95% rh) to a room with an actual SHR equal to or close to 1.0 will result in undersized air coolers!

**Conclusions**

American air cooler manufacturers have traditionally published capacity ratings based on SHR = 1.0 (all sensible) and DT1. European manufacturers typically include latent cooling in their air cooler ratings (i.e. “total” cooling), indicated by an air on relative humidity typically between 85% and 95%. European manufacturers also publish ratings based on either DT1 or DTM, or both. The discussion above illustrates the differences in these rating methods and highlights the importance of selecting air coolers using ratings suited to the operating conditions. Misapplication of DTM and/or total cooling ratings can result in severely undersized air coolers and the consequent failure of the refrigeration system to perform to energy efficiency and cooling capacity expectations.

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