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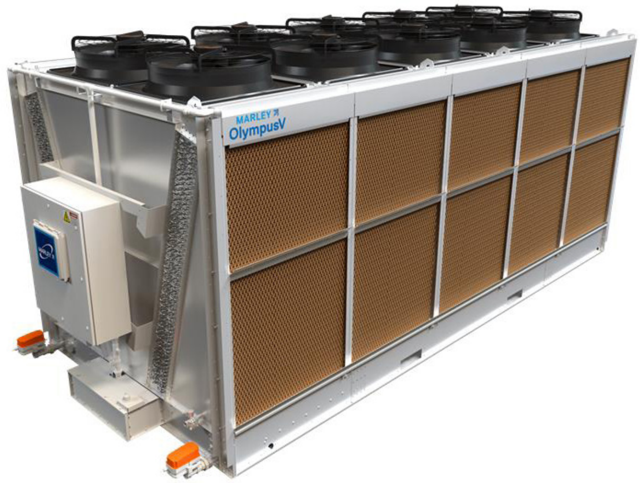
Adiabatic Pad Efficiency Insight

Performance Impact of Saturation Efficiency in Adiabatic Systems



Marley OlympusV® Adiabatic Series

Overview of Adiabatic Systems and Media Types

Adiabatic fluid coolers are becoming more common in industrial and commercial applications due to their ability to reduce water usage compared to traditional evaporative open cooling towers. These adiabatic systems function by a process called adiabatic humidification where ambient air is pre-cooled through the evaporation of water, thereby lowering the air temperature before it contacts the heat exchanger. The pre-cooling efficiency is significantly influenced by method, primarily adiabatic pad media or spray-type systems.

Adiabatic pads are often constructed from materials like cellulose or synthetic fibers and assembled into packs of closely spaced corrugated sheets. These pads are moistened with water, and as air passes through them, evaporation occurs, cooling the air. The design and material of the pads play a critical role in determining saturation efficiency.

Spray-type systems utilize fine mist that is sprayed into the incoming air. While they can achieve high saturation efficiencies, factors such as droplet size, distribution uniformity and evaporation rates are critical for optimal performance.

Saturation Efficiency's Effect on System Performance

Before we compare system types, we must take a closer look at some universal characteristics of adiabatic humidification. The goal of the adiabatic system is to cool the entering air to improve cooling of the process fluid. Efficiency, or ability to cool the entering air, is crucial. Saturation efficiency (η) quantifies the effectiveness of the adiabatic cooling process and is calculated using the formula:

$$\eta = \frac{\text{Ambient DB} - \text{Precooled DB}}{\text{Ambient DB} - \text{Ambient WB}}$$

Where:

- **Ambient DB** is the entering air dry-bulb temperature
- **Precooled DB** is the dry-bulb air temperature after passing through the wetting media
- **Ambient WB** is the ambient wet bulb temperature

For example, consider a scenario when the ambient dry-bulb temperature is 95˚F with a wet-bulb temperature of 78˚F. If the air that passes through a wetted media is cooled to 83˚F, the saturation efficiency is 70.6%

$$\frac{95^\circ\text{F} - 83^\circ\text{F}}{95^\circ\text{F} - 78^\circ\text{F}} = 70.6\%$$

Several variables directly impact saturation efficiency such as:

- **Air Velocity**: Higher air speeds reduce contact time between the entering air and wetted media, therby lowering efficiency.
- **Contact Area**: Adequate contact between entering air and water is essential for performance. Pad thickness and sheet spacing directly influence available surface area for evaporation.

- **Water Distribution**: Uniform water loading ensures consistent wetting and steady evaporation. Insufficient wetting or water loading can lead to scaling and shortened pad life.
- **Maintenance**: Clean, well-maintained media will help prevent airflow blockages that can degrade performance.

A key aspect of spray-type systems is the lack of physical media, which presents its own challenges. In spray-type systems the performance is highly dependent on contact time between the water and air, which is difficult to predict consistently. Fine water droplets may be carried away from the coil by airflow, reducing performance and increasing water loss. The table below shows the advantages and disadvantages of pad vs spray-type adiabatic systems.

Table 1 – Comparison of Pad Media vs. Spray-Type Adiabatic Systems

Variable:	Pad Media	Spray-type
Air Velocity	+	–
Contact Area	+	–
Water Distribution	+	–
Maintenance*	–	– –

*Spray-type systems commonly experience water carryover, leading to scale and corrosion on the heat exchanger. This accelerates the need for unit replacement and is more costly than routine pad maintenance.

Higher saturation efficiency leads to lower air temperatures entering the heat exchanger. This directly affects the overall adiabatic cooler capability. If the saturation efficiency is overstated, the selected unit may be undersized, leading to inadequate cooling for the process. The table below helps demonstrate efficiency impacts.

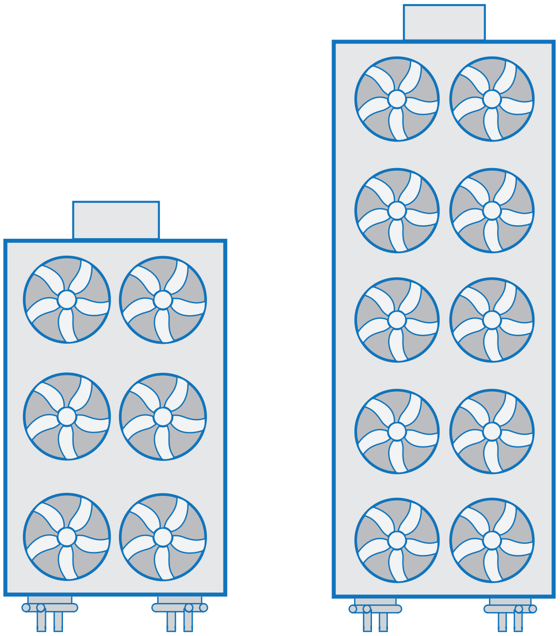
Table 2 – Saturation Efficiency Impacts Approach

Conditions	Case 1	Case 2
Saturation Eff.	**92.0%**	**70.0%**
Ambient DB	97.4°F	97.4°F
Ambient WB	63.5°F	63.5°F
Precooled Air DB	**66.2°F**	**73.7°F**
Approach	**18.8°F**	**11.3°F**
Leaving Fluid Temp.	85.0°F	85.0°F

*Approach = Leaving Fluid Temp – Precooled Air DB

In Table 2, pad saturation has a drastic effect on the precooled air DB temperature and resulting approach temperature. To accommodate this tighter approach, the unit for Case 2, depicted below, is 67% bigger. The outcome is higher purchase price and fan operating energy for Case 2. Additionally, Case 1 may fail to reach specified capacity if claimed saturation efficiency is optimistic and not achievable.

Example 1 – Efficiency Impacts Unit Size



Case #1 **vs.** **Case #2**
30 HP **50 HP**

Saturation Calculations vs. Reality

Manufacturers often provide saturation efficiency values based on ideal laboratory conditions, which may not reflect actual field performance. The previous example demonstrates a possible discrepancy and the effect on unit size. Published adiabatic media test results show measurable differences between claimed and actual saturation efficiencies (see Ref. 3). The table below shows examples at 400 FPM air inlet velocity.

Table 3 – Pad Manufacturers Claimed Efficiency vs. Actual Tested Efficiency

Supplier/ Manufacturer	Claimed Efficiency	Tested Efficiency
A	73%	**70%**
B	92%	**70%**
C	85%	**74%**
D	85%	**75%**

*Manufacturers may claim higher saturation efficiency at a lower air velocity, so comparison at the same air inlet velocity is critical.

Claims of higher saturation efficiency should be viewed with skepticism and scrutinized in more detail prior to purchase.

Why does overestimated saturation efficiency matter?

- *Inaccurate Unit Sizing and Selection*: Relying on inflated efficiency values can lead to undersized equipment that fails to meet cooling demands during peak conditions. This can lead to reduced load capacity or increased process fluid temperatures under peak design conditions, when adiabatic operation is most critical.
- *Dry Switch Point Miscalculations*: Dry switch point - or the ambient temperature at which the system transitions from adiabatic to dry operation - may be set incorrectly, causing the system to run more hours in adiabatic mode. This leads to less system efficiency or higher annual water usage.

Key Takeaways

- **Saturation Efficiency is Critical**: The actual saturation efficiency, whether through wetted media or spray - type systems, has a direct impact on adiabatic system performance.
- **Scrutinize Proposed Efficiencies**: Critically assess manufacturer-provided saturation efficiency values, considering potential discrepancies between lab and field conditions. Inflated saturation values may lead to undersized units and inadequate cooling capacity.
- **Confirm Adiabatic Selections**: Compare technical data between manufacturers before making a purchase decision. How could a unit be 10-40% smaller with comparable coils and pad media? Smaller units with less total fan power and airflow may indicate optimistic saturation efficiency claims that are not achievable.

References

1. Webinar - Adiabatic Fundamentals - SPX Cooling Technologies
2. TP25-25 Managing Water of Adiabatic Systems – CTI Marketplace
3. 19-25 Adiabatic Fluid Coolers and Condensers: Impact of Pad System Design on Saturation Efficiency and Unit Operation – CTI Marketplace
4. Acceptance Test Code for Adiabatic Fluid Coolers ATC-105 Adiabatic – CTI Marketplace

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