driSteem

Evaporative cooling and humidification

High-pressure water atomized, reduces cooling load and energy costs

by Dave Schwaller, Mechanical Engineer
DriSteem Corporation, Eden Prairie, MN

Evaporative high-pressure systems are used to cool and humidify air for processes, products, preservation, and comfort. These flexible systems can be installed in airstreams or directly in the space to be conditioned. They use very little electrical energy to operate and can be located long distances from the air being conditioned. A single system can condition multiple zones and cool supply air directly and/or indirectly through a heat exchanger.

The following characteristics are typical of evaporative high-pressure systems:

Reduced cooling load: The evaporative cooling effect can draw enough heat from the air to produce a 20 °F or more temperature drop. One pound of water evaporated into the air removes approximately 1000 Btu of heat; 12 pounds of water equals about a ton of cooling.

Energy savings: Evaporative high-pressure systems require very little energy to deliver water droplets into the air — about one percent of the energy used by an electric humidifier per pound of water.

Twelve pounds of water evaporated into the air equals about a ton of cooling. Evaporative high-pressure systems provide significant energy savings compared to other evaporative technologies.

Minimal maintenance: Systems using reverse-osmosis (RO) or deionized (DI) water require very little maintenance, particularly if the pump and atomizing nozzles are low- or no-maintenance stainless steel.

Pure, particulate-free cooling and humidification: When using RO or DI water, systems with high-grade stainless steel parts can disperse atomized water particles without dispersing bacteria, viruses, or minerals.

High capacity: In air handlers and ducts, capacity is limited only by duct or air handler size and evaporation capability. In open spaces, very large capacities can be met with a single system or with multiple smaller systems.

Evaporative cooling and humidification psychrometrics

Table 2-1 presents how an evaporative high-pressure system can be configured for regional outside conditions and reconfigured for seasonal changes. Operating conditions for each scenario are charted in Figure 3-1.

<table>
<caption>Table 2-1: Seasonal/regional scenarios and evaporative high-pressure system design factors</caption>
<tr><th rowspan="2">Scenario</th><th colspan="4">Outside air operating conditions</th><th colspan="5">Design factors</th></tr>
<tr><th>Wet bulb (°F)</th><th>Dry bulb* (°F)</th><th>Dew point (°F)</th><th>RH %</th><th>Outside air %</th><th>Evaporative high-pressure system status**</th><th>Supply air dry bulb (°F)</th><th>Supply air dew point (°F)</th><th>Room dew point (°F)</th></tr>
<tr><td>A</td><td>< 53</td><td>—</td><td>< 42</td><td>—</td><td>Minimal to 100</td><td>Staging / Modulating</td><td>64</td><td>42</td><td>—</td></tr>
<tr><td>B</td><td>> 53</td><td>—</td><td>< 42</td><td>—</td><td>Minimal to 100</td><td>Staging / Modulating</td><td>64 to 81</td><td>42</td><td>—</td></tr>
<tr><td>C</td><td>—</td><td>> 64
< 81</td><td>> 42
< 60</td><td>< 60</td><td>100</td><td>Bypassed</td><td>64 to 81</td><td>42</td><td>—</td></tr>
<tr><td>D</td><td>< 66</td><td>> 81</td><td>> 42</td><td>—</td><td>Minimal to 100</td><td>Staging / Modulating</td><td>81</td><td>42 to 59</td><td>—</td></tr>
<tr><td>E</td><td>> 66
< 76</td><td>> 81</td><td>> 42</td><td>—</td><td>Minimal to 100</td><td>Staging / Modulating</td><td>81</td><td>42 to 59</td><td>—</td></tr>
<tr><td>F</td><td>< 76</td><td>< 81</td><td>> 59</td><td>—</td><td>Minimal to 100</td><td>Bypassed</td><td>60 to 81</td><td>59</td><td>> 59</td></tr>
<tr><td>G</td><td>—</td><td>< 64</td><td>> 42
< 59</td><td>—</td><td rowspan="2">Minimal to 100</td><td rowspan="2">Bypassed</td><td rowspan="2">≥ 64</td><td rowspan="2">42 to 59</td><td rowspan="2">42 to 59</td></tr>
<tr><td>H</td><td>—</td><td>> 64</td><td>< 59</td><td>> 60</td></tr>
</table>

* Dry bulb temperature includes heat gain from the supply fan.
** When evaporative cooling cannot meet the cooling requirement, supplemental cooling is required.

Figure 3-1: Outside air operating conditions on the psychrometric chart

Scenarios from Table 2-1 are defined by the red borders in this chart, which characterize year-round, seasonal differences for a specific application.

Table 2-1 design factors are based on the required supply conditions (Scenario C in the table, and region C in this chart).

Note: Region C in this chart is the design range for supply air.

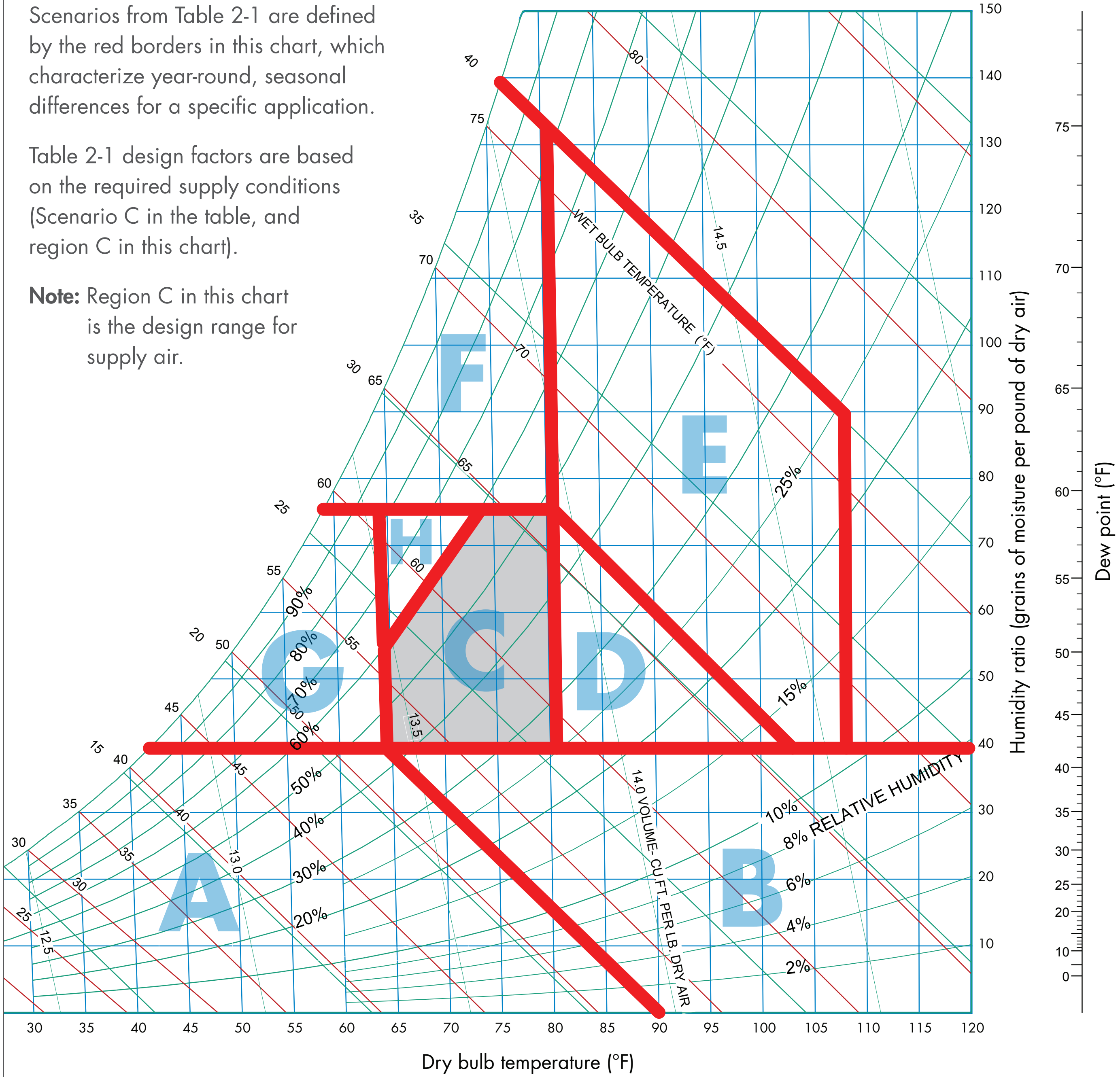


Chart courtesy of Hands Down Software, www.handsdownsoftware.com

Evaporation efficiency in air handlers and ducts

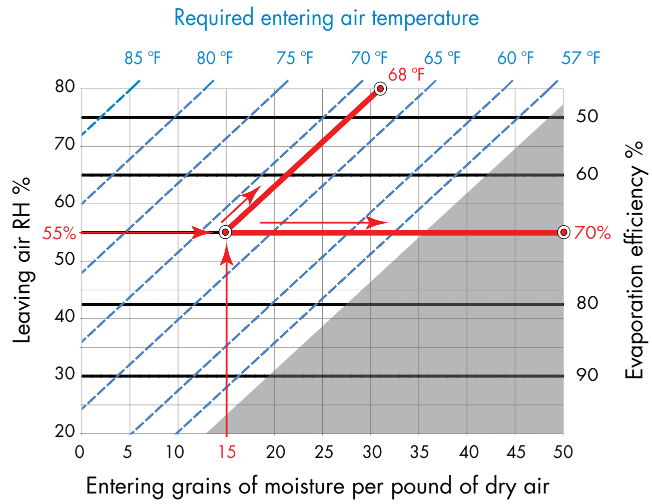
Factors affecting evaporation efficiency

Once water is dispersed into a moving airstream, many factors affect evaporation efficiency, or how much of that water will evaporate.

The main factors are leaving RH, leaving air temperature, and available evaporation distance.

Other factors include humidification load, air velocity and velocity profile, entering air dew point temperature, and duct or air handler design and components.

Figure 4-1: Evaporation efficiency chart*



Using 55% leaving air RH and 15 grains of moisture per pound of dry air, the chart identifies:

- 68 °F required entering air temperature
- 70 % evaporation efficiency

With load and evaporation efficiency known, required system capacity can be calculated:

$$\frac{\text{Load}}{\text{Evaporation efficiency}} = \text{Required system capacity}$$

$$\frac{385 \text{ lbs/hr}}{0.7} = 550 \text{ lbs/hr}$$

* Evaporation efficiency shown here is based on 4-ft evaporation distance, 55 °F leaving air temperature, and 500 fpm air velocity.

Find evaporation efficiency charts for additional evaporation distances and air handler/duct conditions on the **Literature** tab of our website.

For more about evaporative high-pressure systems, visit: **www.dristeem.com/high-pressure-system**

DriSteem can help you with application-specific design issues. Find your nearest DriSteem Representative on our Home page: **www.dristeem.com**

DRI-STEEM Corporation
A subsidiary of Research Products Corporation
DriSteem is an ISO 9001:2000 certified company

U.S. Headquarters:
14949 Technology Drive
Eden Prairie, MN 55344
800-328-4447 or 952-949-2415
952-229-3200 (fax)

Form No. Evaporative high-pressure system white paper 1014