MSP® WRAP-AROUND MULTIPLE SMALL PLATE DEHUMIDIFICATION TECHNOLOGY VS. CONVENTIONAL DEHUMIDIFICATION IN DEDICATED OUTDOOR AIR SYSTEMS (DOAS)

++

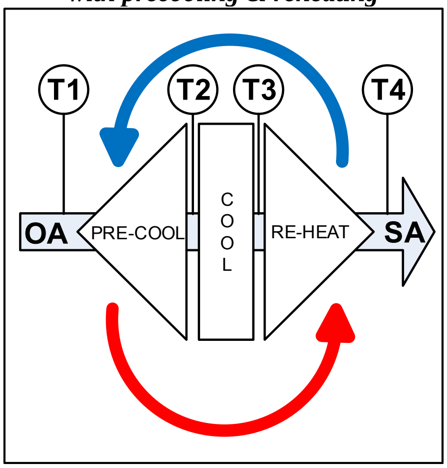
A white paper presented by Walter Stark, President of MSP® Technology (wstark@msptechnology.com)

MSP's wrap-around plate technology offers superior efficiency removing moisture from outdoor air.

MSP® Wrap-around plate technology

MSP's wrap-around multiple small plate is the system of using air-to-air plate heat exchangers to precool and then reheat air in the dehumidification process. A conventional dehumidification system, does no precooling and reheats using waste heat from the refrigeration system. Compared with Conventional dehumidification, MSP's wrap-around plate systems have lower operating costs.

Figure 1- MSP Dehumidification with precooling & reheating



Wrap-around plate precools (T1-T2)
Saving significant energy (T2-T3)

The MSP wrap-around *plate* dehumidification technology offers significant precooling, which reduces the load and energy consumption of the cooling coil, thus saving operating costs. MSP uses nearly one square foot of plate heat transfer surface per cfm of air, which accounts for MSP's superior performance. In the example below, close to 4,500 square feet of heat transfer surface is used.

Comparison of MSP® with a hot-gas system

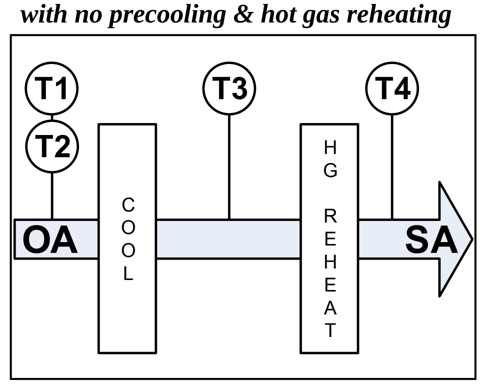
MSP (Fig. 1, left) uses cold air leaving the process (T3) to precool outdoor air. A single continuous airstream (T1) is pre-cooled (T2) before passing through a cooling coil (T3), and then reheated (T4).

Hot gas reheat systems (Fig. 2, below right) do not have a pre-cooling feature and thus have increased Btu, compressor horsepower and electrical load. Hot gas reheat systems have to expend more energy for cooling.

Decoupling

MSP improves the overall efficiency of a DOAS working with a "decoupled" building heating and cooling system. *Decoupling* leaves the building's air conditioning system to control its temperature, while the outdoor (DOAS) unit controls the building's humidity. Neither function can overpower the other. They work separately, yet in harmony. Air delivered by the DOAS is at a dew-point that is equal to (*neutral*) or lower than the building's dew-point. Zone temperature control remains the job of the building temperature control system.

Figure 2- Conventional Dehumidification with no precooling & hot gas reheating



No precooling uses more energy

Heat, when added to cold and dehumidified outdoor air, increases the load in zones that are already in a cooling mode. This is true of both systems. However, systems employing wrap-around reheat, such as MSP, have an added feature; ***Precooling dramatically reduces the dehumidification load and thereby neutralizes the effect of supplying temperatures that may be higher than zone set-point.*** Usually, the effect on the zone sensible load is small enough to ignore. If not, post-cooling at the DOAS unit can be employed for the few hours surrounding peak design dry-bulb temperature.

DOAS equipment with MSP Dehumidification Technology, is designed to maintain supply air dew-point, while dry-bulb temperature "floats" naturally, in relation to outdoor air temperature. Warm hours of the day will result in higher supply air temperature. Nevertheless, ***each uninvited Btu of reheat is matched to a welcome Btu of energy-saving precooling***. Btu's of reheating that exceed zone temperature have their energy-saving (precooling) counterpart.

The effect of climate on overall performance

Design conditions often serve as basis for judging overall performance. But design conditions occur for only a fraction of the time. This is especially true of applications with extended hours of operation such as hospitals, hotels, barracks, assisted living, and dry storage, because lower nighttime temperatures bring the average down.

The performance of the MSP DOAS actually improves at lower dry-bulb temperatures, which occur for most of hours in a dehumidification season. To understand the benefit of MSP in a DOAS application, we will evaluate the energy consumption of both systems using Atlanta, GA as an example.

Performance analysis using Atlanta GA

Table 1 (below), illustrates the performance of MSP and conventional dehumidification in Atlanta, GA, using conditions representing the *average* dry-bulb and dew-point temperatures (73.2°F/63.1°F). These values were derived from TMY3 data and include only hours when the outdoor dew-point is greater than 50°F. These values are supported in the data analysis section below.

Table 1 - MSP vs. hot gas reheat performance at 4,500-cfm in Atlanta, GA

SYSTEM	T1 (db/dp)	T2 (db/dp)	T3 (db/dp)	T4 (db/dp)	Btuh
MSP (FIG 1)	73.2°F/63.1°F	62.5°F/58.0°F	50.0°F/50.0°F	70.2°F/50.0°F	118,900
CONVENTIONAL (FIG 2)	73.2°F/63.1°F		50.0°F/50.0°F	70.2°F/50.0°F	217,000

Figure 3 (below) shows details of the MSP psychrometric performance shown in Table 1 (above). Inlet conditions are the average of annual dry-bulb and dew-point temperatures during active dehumidification hours, when the dew-point greater than 50°F.

Figure 3 – MSP Psychrometric Analysis

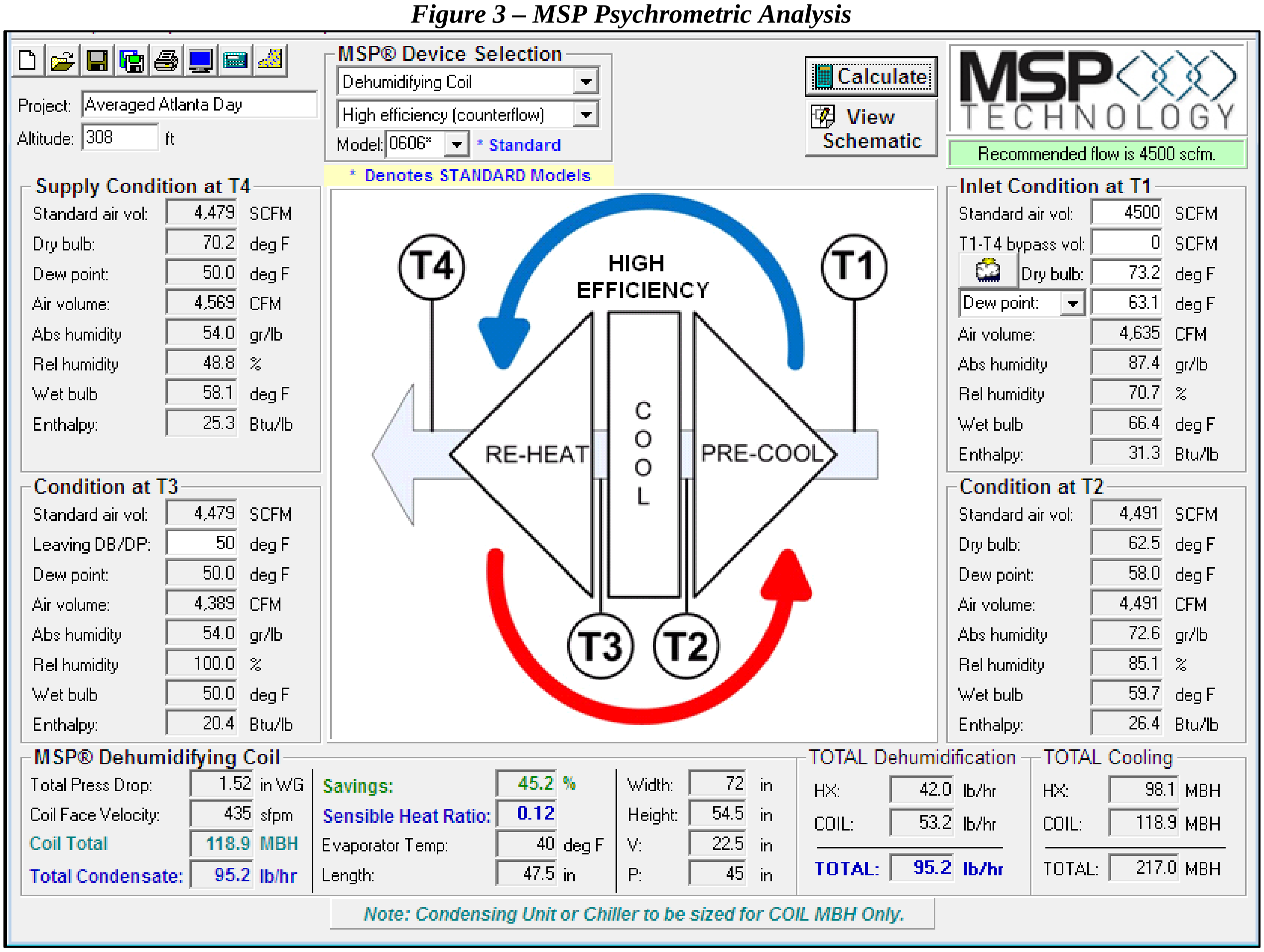
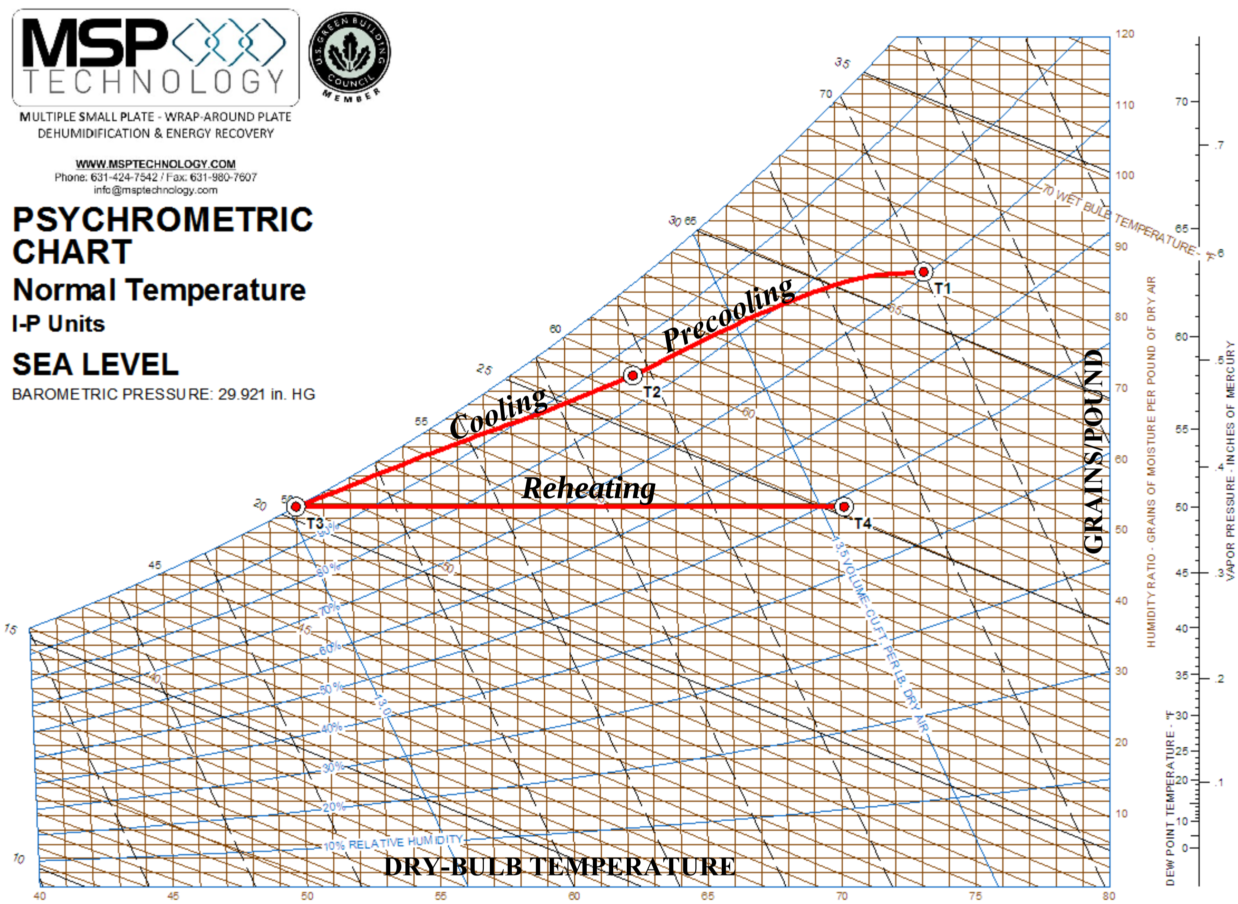


Figure 4 (below) shows the psychrometric chart profile, based on table 1 (above).

Figure 4- MSP Psychrometric Chart



NOTE: Chart shows MSP DOAS profile. Conventional DOAS profile is similar.
Outdoor air travels directly from T1 to T3, with *no precooling and* T3 to T4 is hot gas reheat.

Data analysis – Atlanta, GA

This analysis uses TMY3 data provided by the United States National Solar Radiation Data Base.

Table 2 (below), confirms that the maximum average outdoor temperature for any month in Atlanta, GA does not exceed 80°F while ASHRAE tables, for 0.4%, put the design outdoor temperature at 93.9°F. It is important to consider that the *average* outdoor temperature entering the DOAS is significantly lower than design outdoor temperature.

Table 2 - Average monthly dry-bulb temperatures & associated hours, using TMY3 climate data in Atlanta, GA

MONTH	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
DRY-BULB (°F)	39.1	46.3	56.8	63.0	69.5	76.6	78.9	79.8	72.5	60.8	53.5	45.9
HOURS	744	672	744	720	744	720	744	744	720	744	720	744

Total hours: 8,760

Table 3 (below), illustrates the monthly average dry-bulb and dew-point temperatures that occur when the outdoor dew-point is greater than 50°F, which is a typical set-point for a DOAS system.

Table 3 - Average monthly dry-bulb & dew-point temperatures & hours
when outdoor dew-point is greater than 50°F in Atlanta, GA

MONTH	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
DRY-BULB (°F)	57.2	57.9	67.2	66.1	70.8	77.9	78.9	79.8	72.6	66.2	64.2	60.2
DEW-POINT (°F)	55.0	55.4	55.2	57.3	59.9	64.4	67.7	69.3	62.7	59.8	57.7	55.6
HOURS	53	84	168	301	601	627	744	744	697	345	164	91

Total hours: 4,619

Hot gas reheat has diminishing returns

The formula for calculating the energy available for hot gas reheat is:

EVAPORATOR BTUH + (COMPRESSOR KW X 3,414) = AVAILABLE REHEAT ENERGY BTUH

From this formula we know that energy available for reheating decreases with evaporator Btuh. We also know that as evaporator load decreases, reheat requirement increases.

To increase the reheat capability of the refrigeration system under low evaporator load conditions, the compressor KW must increase. This can be accomplished by raising the refrigeration system condensing temperature, but the net result of this measure is equal to electric resistance heat. It would be better to avoid the wear and tear on the compressor and simply use the winter heating source, which is generally equal to, or lower than, the cost for electric resistance heat.

Hot gas reheat with a building in cooling mode

Building zones with higher cooling loads require lower supply air temperature, while zones with lower cooling loads require higher supply air temperature. Thus, a conventional DOAS system employing hot gas reheat and serving multiple zones, can only truly satisfy one zone. The remaining zones must compensate with additional cooling to overcome excess hot gas reheat. This is clearly wasteful. Undesired heating in zones will respond with undesired cooling in the same zones. To avoid over-cooling some zones, a higher supply air temperature is required for all zones.

MSP reheat with a building in cooling mode

MSP reheat is "efficient reheat" because it has an energy-saving precooling counterpart. Even when it is overheating some zones, it is doing so efficiently with no energy waste.

The MSP DOAS dehumidification solution offers a very efficient means for controlling supply air dew-point temperature. In this system the supply air dry-bulb temperature "floats" relative to outdoor dry-bulb temperature. Sensible cooling is shifted to the individual zone temperature controls which can now be very effective and very efficient dealing largely with sensible heat (temperature change) rather than latent heat (humidity change).

The influence of climate, application and utility rates, on ROI

To get a true picture of the energy use of different DOAS solutions, we must move beyond evaluation of performance under one "design condition." For a complete evaluation, we need to analyze annual performance under a full range of climates, applications and utility rates.

Climates: As we move toward coastal areas and closer to the equator, annual hours of exposure to high humidity and temperature increase. These areas can benefit significantly from MSP® Technology because of longer season which equates to more equipment run-time and fast return on investment.

Application: Many dehumidification applications have 24-7 operation. These include hospitals, hotels, barracks, dry storage and many more. Places with extended hours of operation are excellent candidates for MSP because longer run-time means faster return on investment. In chilled water applications, compressors and refrigeration components are eliminated, making MSP chilled water dehumidification an especially good application for improving ROI.

Utility rates: Locations with high utility costs can benefit significantly from using MSP with wrap-around reheat because savings on high utility rates result in faster return on investment.

Fan power

Fan power energy is higher with the MSP solution due to added pressure drop through the heat exchangers. The added fan power, in the Atlanta, GA example is estimated at ~2000 kWh during 4619 active dehumidification hours. Dehumidification savings for this period far outweigh fan power cost. When system is inactive, an optional bypass damper opens, eliminating pressure drop through the entire dehumidifier section. With this feature, the benefit during inactive hours can offset the added cost during active hours.

Conclusion

When MSP wrap-around plate technology is used to treat outdoor air in a DOAS application, the combined DOAS and building systems operate more efficiently than conventional dehumidification systems. With nearly one square foot of aluminum heat transfer surface per cfm of processed air, the MSP solution offers superior performance. In chilled water applications compressors and refrigeration components are eliminated, making chilled water dehumidification an especially good application.

The amount of ***hot gas reheat energy*** used in a conventional DOAS system would be roughly equal to the amount of thermal energy savings achieved by an equivalent MSP DOAS system.

MSP offers custom and standard models of High Efficiency Chilled Water, Packaged and Split Dehumidification Systems.

We hope that we have stimulated some thought. Please send your comments to: wstark@msptechnology.com