ENERGY

REDUCTION OPPORTUNITY

REGARDING

MECHANICAL COOLING

VIA DX REFRIGERATION

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DEFINITIONS

<u>DRY BULB TEMPERATURE</u>

A measurement of temperature usually expressed in degrees Fahrenheit or degrees Celsius, measured with a thermometer.

<u>WET BULB TEMPERATURE</u>

The lowest temperature that evaporation of water causes, measured using a thermometer with a wet wick over its bulb.

<u>RELATIVE HUMIDITY</u>

The percentage of moisture contained in air relative to the air saturated at that dry bulb temperature.

<u>ENTHALPY</u>

The total heat content of air, considering the dry bulb temperature and the relative humidity. (Every pound of evaporated water contains 970 BTU of latent heat, as well as its sensible heat.)

<u>SENSIBLE HEAT</u>

Heat added or taken from a substance that changes the dry bulb temperature of that substance.

<u>LATENT HEAT</u>

Heat absorbed or discharged from a substance as that substance changes state from solid to liquid, liquid to solid, gas to liquid or liquid to gas. Latent heat loss or gain does not change the dry-bulb temperature of the substance.

VALUES

-1- 7,000 grains of moisture = one pound
-2- 13.35345 cubic feet of air = one pound
-3- 970 BTU’s are required to evaporate one pound of water
-4- 970 BTU’s are produced in condensing one pound of water vapour
-5- .018 BTU’s are required to raise one cubic foot of air one Fahrenheit degree

EXECUTIVE SUMMARY

This paper addresses a means of reducing the total annual running hours of mechanical cooling compressors in DX applications, while maintaining exactly the same dry bulb temperature in the occupied space.

The subject systems have outdoor, exhaust and return air dampers with an enthalpy comparison economizer circuit. During warm weather, typically these systems position the dampers at either 100% outdoor air or primarily return air with minimum outdoor air, addressing ventilation requirements. The circuit selects the air stream with the lesser total heat content (enthalpy) to pass through the refrigeration coil. This is the most efficient means of mechanical cooling, when the refrigeration compressor is running and tends to reduce the run time of the refrigeration compressor. If the particular unit runs properly with potentially low load conditions, this is the correct operation of the DX mechanical cooling, minimizing compressor run time.

With the compressor run time minimized, we now have to consider the duration of the rest time, when the refrigeration compressor is inactive, but the fan is running. The magnitude of both the run time and the rest time determine the annual run time of the refrigeration compressor.

When the controlled space cools to the bottom of the cooling dry bulb differential range, the refrigeration compressor shuts down, the fan continues running, providing the required ventilation, respecting building codes. The dampers conventionally maintain their position based on the air stream with the lesser enthalpy.

The cycling of the refrigeration compressor is based on dry bulb temperature of the occupied space, not enthalpy. The cooler the supply air is to the controlled space, while the refrigeration compressor is inactive, the longer the rest time of the refrigeration compressor.

Consider an outdoor condition of 80°F, with lesser enthalpy than a return air condition of 73°F. Conventional systems, based on enthalpy control of the dampers, maintain an 80°F supply air, while the refrigeration compressor is inactive; however, this new circuit switches to a 73°F supply air (approximately), when the refrigeration compressor is inactive. Supply air of approximately 73°F causes a longer rest time, prior restarting the refrigeration compressor, than the 80°F supply air.

When the outdoor air enthalpy is less than the return air enthalpy, the dry bulb temperature of the return air is less than the dry bulb temperature of the outdoor air and the refrigeration compressor is inactive, switch the dampers to return air. This will maximize the rest time of the refrigeration compressor**.**

Combining enthalpy logic when the refrigeration compressor is active with dry bulb logic when the refrigeration compressor is inactive, minimizes the annual run time of the refrigeration compressor, while maintaining identical dry bulb temperature conditions in the occupied space.

ENERGY OPPORTUNITY REGARDING DX COOLING

This paper addresses a significant opportunity regarding HVAC systems with full mixing dampers, limited by a mixed air controller and an economiser controlled via enthalpy comparison of the outdoor air and the return air. The mechanical DX cooling, which cycles the refrigeration compressor via dry bulb temperature, is controlled from either the return air or the occupied space.

A logical control system should run the refrigeration compressors for the least amount of time, while maintaining comfort level in the occupied space. This is achieved by minimizing the refrigeration compressor run time and maximizing the compressor rest time. In order to achieve this situation we must view damper economiser control from a new perspective.

An enthalpy logic circuit calculates the outdoor air enthalpy and the return air enthalpy. The air stream with the lesser enthalpy is selected as the air stream passing through the evaporator coil of the refrigeration cooling system.

For example:

-The thermostat starts the refrigeration compressor when the room temperature rises to 76°F and stops the refrigeration compressor when the room temperature reduces to 72°F.

-Return air 76°F at 40% RH contains 26.61 BTU/lb of dry air.

-Return air 72°F at 51% RH contains 26.61 BTU/lb of dry air. (%RH rises as the room cools, with the same moisture content.)

-Outdoor air 80°F at 15% RH contains 22.76 BTU/lb of dry air.

In this example, enthalpy logic chooses to position the mixing dampers to 100% outdoor air, as this air stream has a lesser enthalpy value. (22.76 BTU < 26.61 BTU) This is the correct choice when the refrigeration compressor is running, as a lesser amount of heat exists in the outdoor air than the return air; therefore, the compressor run time will be minimized.

Now consider the rest time of the refrigeration compressor, as the room temperature rises from 72°F to 76°F. Heat gain factors such as body load, light load, solar load, machine load, etc. are a constant, regardless if the fan's mixing dampers are on 100% outdoor air or on return air with minimum outdoor air and will not alter the rate of temperature gain when the refrigeration compressor is resting or running.

Keep in mind that the refrigeration compressor is controlled via dry bulb temperature. If the system is on 100% outdoor air at 80°F, the time for the room to rise from 72°F to 76°F will be less than if using the return air at 72°F to 76°F, with all other cooling loads being equal.

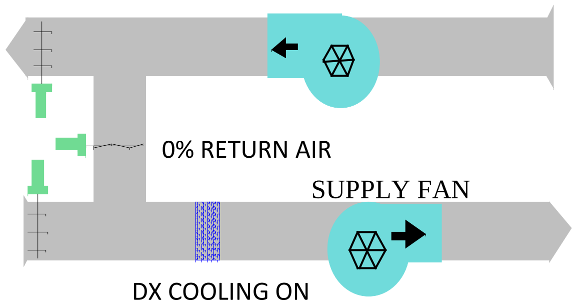
If the refrigeration compressor is running, the dampers should be positioned to the air stream with the lesser enthalpy, which will minimize the compressor run time.

If the refrigeration compressor is cycled off, when the outdoor enthalpy is less than the return air enthalpy, but the return air dry bulb temperature is less than the outdoor air temperature, select the return air with just minimum outdoor air, which will maximize the compressor rest time.

If the return air enthalpy is less than the outdoor air enthalpy, but the outdoor dry bulb temperature is less than the return air dry bulb temperature, do not switch to the cooler outdoor air, when the refrigeration compressor is not running, as you may flush the building with moist air, which will cause a greater cooling load when the refrigeration compressor running.

ENERGY OPPORTUNITY EXAMPLE, REGARDING DX MECHANICAL COOLING

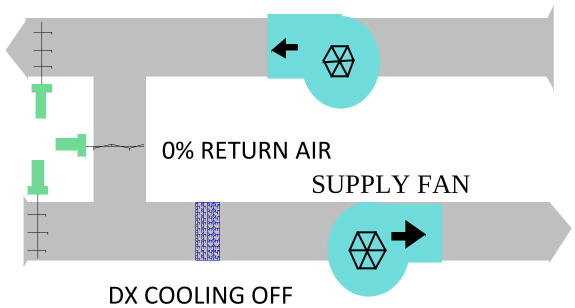
SCENARIO “A”



Scenario “A” illustrates a fan system, when the DX cooling compressor is active. Enthalpy comparison determines the heat content of the return air and outdoor air. The system dampers are on full outdoor air, as the total heat content of the outdoor air is approximately 14.5% less than the total heat content of the return air. Selecting the air stream with the lesser heat content causes the refrigeration compressor run time to be minimized.

SCENARIO “B”

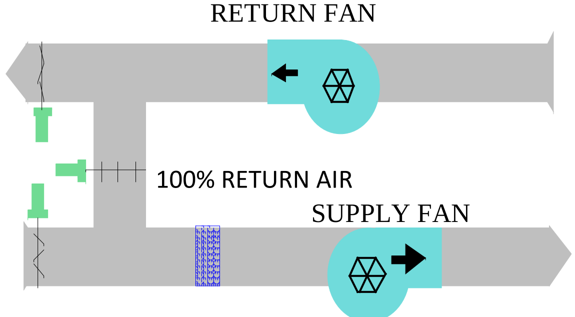
(CONVENTIONAL LOGIC)



Scenario “B” illustrates the fan system, when the DX cooling compressor is not active. Enthalpy comparison determines the heat content of the return air and outdoor air. The dampers are on full fresh air, as the outdoor air contains 14.5% less total heat than the return air.

SCENARIO “C”

(CONSERVATION LOGIC)



Scenario “C” illustrates the fan system when DX cooling compressor is not active. Cycling the mechanical cooling is based on dry bulb temperature of the space; therefore, the **rest** time of the mechanical cooling will be greater if the supply air is at the lower dry bulb temperature of the return air than the higher outdoor air.

SUMMARY

The mixing dampers should be positioned based on return air and outdoor air enthalpy comparison when the mechanical cooling is active, lessening the run time of the mechanical cooling.

The mixing dampers should revert back to minimum ventilation, when the mechanical cooling is at rest, if the return air temperature is less than the outdoor air temperature, increasing the rest time of the mechanical cooling.

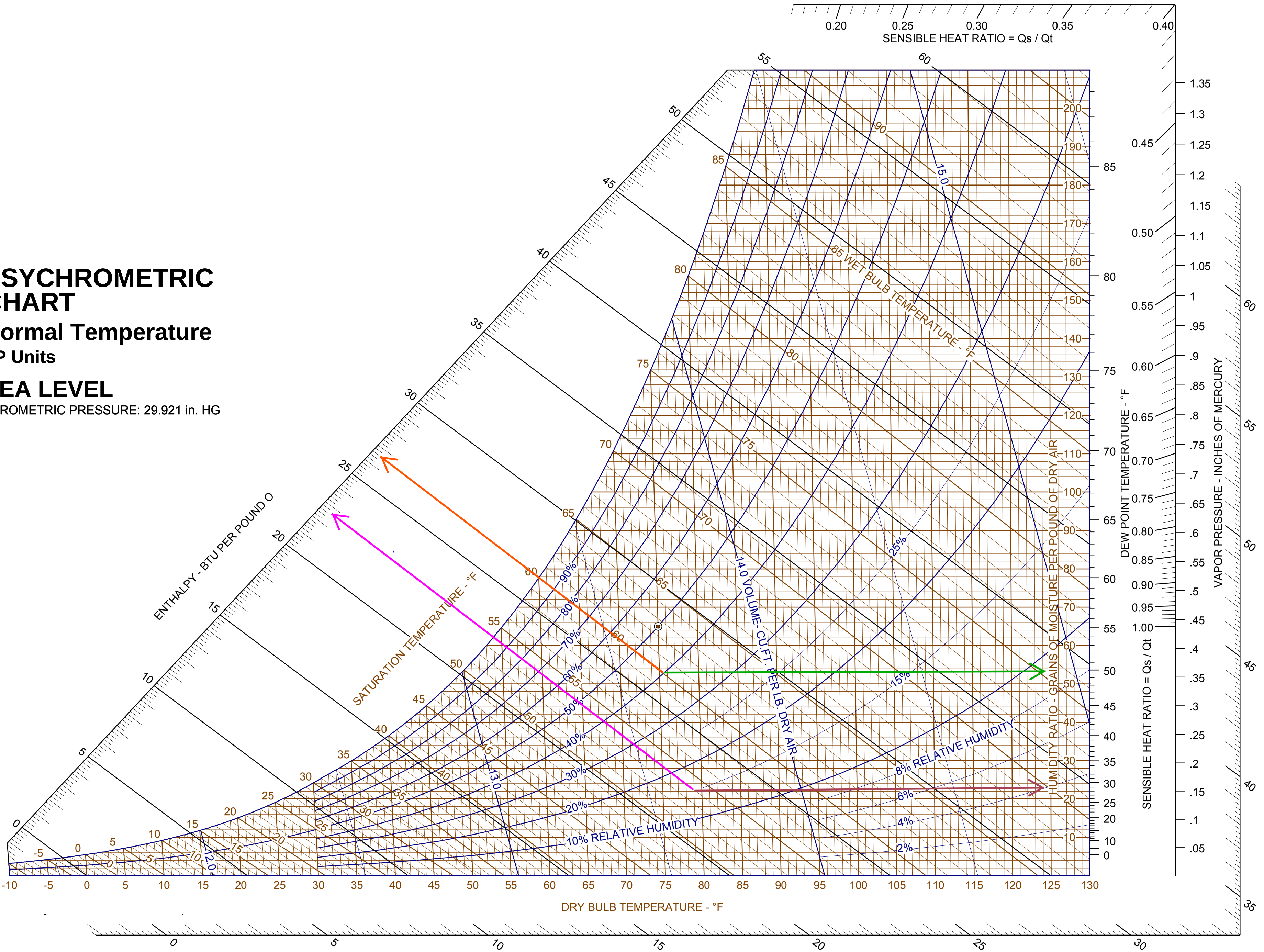
PSYCHROMETRIC CHART

Normal Temperature

I-P Units

SEA LEVEL

BAROMETRIC PRESSURE: 29.921 in. HG



ENERGY CONSERVATION BENEFIT OF ENTHALPY COMPARISON IN HVAC

Energy conservation benefit regarding enthalpy comparison is significant. If owners, operators and service technicians have a true practical understanding of their importance in maintaining the control logic, they will better fill their respective roles of good management, proper monitoring and precise calibration.

The psychrometric chart on page four high lights the thermal characteristics of the return air and outdoor air illustrated in the sample drawing on page three.

The orange and green lines follow two psychrometric characteristics of the example return air. The orange line overlays the enthalpy line starting at 76° F at 40% RH running up to the enthalpy value of 26.61 BTU per pound of dry air. The green line overlays the moisture content line running to the value of 53.5 grains of moisture per pound of dry air.

The pink and brown lines follow two psychrometric characteristics of the example outdoor air. The pink line overlays the enthalpy line starting at 80° F at 15% RH running up to the enthalpy value of 22.76 BTU per pound of dry air. The brown line overlays the moisture content line running to the value of 22.5 grains of moisture per pound of dry air

Each pound of evaporated water produces 970 BTU's of heat, as it condenses from gas to liquid. This latent heat of evaporization often causes cooler, moist air to consume more cooling energy than warmer dry air. Enthalpy comparison loops tend to minimize the condensing of moisture at the cooling coil.

On page four the saturation temperature figures following the 100% humidity line toward the left side of the chart present the temperatures (dew point) where the air is not capable of holding more moisture than the grains of moisture per pound of dry air scale figure you see if you draw a line straight across the graph to the far right.

The target supply air temperature for cooling is often 55° F.

As the return air cools to 55° F, it becomes saturated at 60°F, containing 78 grains of moisture per pound of dry air. At 55° F the air is only capable of holding 64 grains of moisture per pound of dry air; therefore, 14 grains of moisture must be condensed out of the air as it cools from 60° F to 55° F. The latent heat of evaporization, as it condenses, plus the sensible heat reduction of the air, must be addressed by the cooling system.

As the 80° F outdoor air, at 15% RH, cools to 55°F, the relative humidity level rises to only 95.5% RH; therefore, no condensing takes place, allowing only sensible heat as the cooling load.

Based on 20,000 CFM, when the refrigeration compressor is running, the cooling load, using return air completely, is 7,560 BTU's sensible heat plus 2,906 BTU's latent heat = 10,466 BTU's total.
Based on 20,000 CFM, when the refrigeration compressor is running, the cooling load, using outdoor air completely, is 9,000 BTU's sensible heat and no latent heat = 9,000 BTU's total.
The cooling energy required by DX mechanical systems not comparing enthalpy, under the sample conditions, is 16.3% over a system comparing return air and the outdoor air enthalpy.

Regarding the example figures, when the refrigeration compressor is resting, enthalpy control of the dampers will add an extra 15.7% more sensible heat to the air supply, shortening the refrigeration compressor rest time. The net result will be more running time for the refrigeration compressor with absolutely no temperature difference in the space served.

This logic could be applied to two position control, with chilled water, in some applications.

Respecting our common environment, you may use this paper for training purposes if you wish.