Rittal White Paper 305: Selecting Air Conditioners for Industrial Enclosures

By: Judith Koetzsch

Mark Corcoran, Editor

Executive Summary

Choosing the right air conditioners for enclosures can have a tremendous impact on the overall performance and efficiency of industrial operations. Proper and efficient air conditioner cooling can significantly prolong the life of installed equipment, save energy and utility costs, and protect against unscheduled downtime. Although cooling is sometimes an afterthought during the course of planning a project at the enclosure layout level, with careful consideration and the right information, it can truly become an asset for increased productivity and profitability.

This paper identifies different factors that should be considered when choosing air conditioners for industrial enclosures including internal heat loads, the various methods used to rate the cooling capacity of enclosure air conditioners, the impact of humidity and other ambient conditions, and energy efficiency. Understanding air conditioner performance diagrams and sizing tools in relation to application requirements is also covered.

Factors to Consider

Internal Heat Load

The internal heat load is the amount of heat energy produced by the electronics inside the enclosure, and it comes from the unused electricity running through the components. In order to specify the right air conditioner capacity for an application, it is critical to know the amount of heat energy (in BTU per hour or in Watts) that will be created by the equipment housed within the enclosure.

How to Determine the Amount of Heat Energy to be Removed?

There are multiple ways to determine the heat load inside an enclosure. One way is to add up the heat loads of all of the installed electronic components as specified by the component manufacturers as seen below.

Example:

Device	Heat load as specified by the manufacturer
20 HP Drive	1500 Watts
1250 A Circuit breaker	200 Watts
PLC 5 A	3 Watts
Transformer 1000 VA	64 Watts
Total	**1667 Watts**

Another approach is to add up the electricity consumed by the electronics and then multiply it by the efficiency of the system. The resulting number equals the need for cooling capacity. For example, if an electronics system is consuming 500 Watts of power and it is 20% efficient, the system is only using 100 Watts of electricity for its actual function. The remaining 400 Watts is dissipated in the form of heat energy.

Impacting Cooling Capacity

In the world of electronics, cooling capacity is the maximum amount of thermal energy that a climate control product can remove, and it is shown either in Watts or BTU per hour (if necessary, to convert Watts into BTU per hour, multiply by 3.413). The cooling capacity, or performance, of a specific enclosure air conditioner not only depends on its overall design, but also on various application-specific factors. These factors include the ambient temperature, the maximum allowable internal temperature, and the operating frequency (in Hz).

The ambient temperature (T_a) can significantly affect the cooling capacity of an air conditioner. If an air conditioner operates in high ambient temperatures (for example, the maximum operating temperature for Rittal TopTherm air conditioners is 131° F), it provides less cooling capacity. This is because air conditioners work by pulling the hot air from inside the electrical enclosure and transferring the thermal energy away from the cabinet to the surrounding environment. The hotter the outside air is, the ability of the air conditioner to transfer the enclosure heat energy out through the condenser coil is diminished. As to be expected, the opposite is true when air conditioners are placed in areas with lower ambient temperatures since the heat transfer through the condenser coil into the ambient air is quicker, consequently raising the cooling capacity of the air conditioner.

The maximum allowable internal temperature (T_i) is also relevant to the cooling capacity of an air conditioner because it determines how much thermal energy needs to be removed from an enclosure and can vary from application to application. Typically, air conditioners operate by maintaining temperatures that do not exceed a specified set point. A recommended set point for enclosure air conditioners lies between 86° F and 104° F, depending on the electronics installed in the enclosure. Lower temperature set points can easily lead to excessive condensation and should be avoided.

Example:

The set point of an air conditioner is set to 95° F and the differential (or switching hysteresis) setting is 9° F. The temperature inside the enclosure is allowed to increase to 95° F before the air conditioner starts to run to cool the temperature down to 86° F. Now that the differential to the set point has been reached, the air conditioner shuts off until the enclosure temperature rises to the set point of 95° F again.

The third factor that influences the cooling capacity of an air conditioner is the operating frequency. Here in North America, 60 Hz is the norm, but throughout much of the world, 50 Hz is used. This is why, for example, most Rittal TopTherm Plus air conditioner models are dual-rated, meaning that they can operate at both 50 and 60 Hz. A dual rating allows for the same air conditioner to be used all over the world where different power systems supply different frequencies. When an air conditioner is operating at 60 Hz, the fans and compressor actually rotate faster than at 50 Hz, resulting in higher performance for the air conditioner at 60 Hz.

When evaluating an air conditioner stated to have a certain cooling capacity, it's important to consider under what temperature conditions, and at which operating frequency, that cooling capacity is provided.

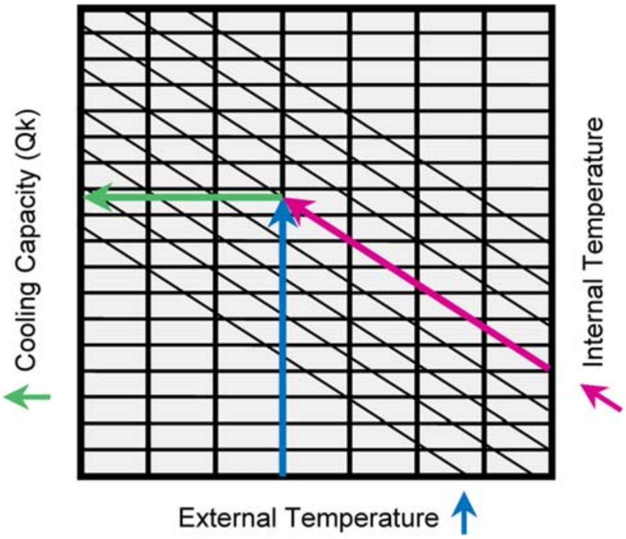
Why Some Manufacturers Determine Cooling Capacity Differently than Others
In North America, no formal standard for testing or publishing cooling capacity exists, so most manufacturers use the maximum temperatures at which the air conditioner is designed to operate as reference points (maximum internal and external temperatures). The maximum operating temperatures can differ between air conditioner models as well as manufacturers. Typically, a maximum operating temperature is at 131° F. If indicated, the rating temperatures could be shown as L131/L131 or Ti 95/Ta 95 or 95° F/95° F. Traditionally the first number stands for the internal temperature.

In Europe, a standard called DIN 3168/EN 814 part 500 (European standard for enclosure climate control) is used. This standard levels the playing field, and provides a more realistic measure of performance, by requiring all manufacturers to use the same temperature conditions to determine cooling capacity—allowing users to make true one-to-one comparisons.

Since Rittal is a global supplier of enclosure air conditioners, the cooling capacities shown on its units comply with existing standards.

Helpful Tools

Air Conditioner Performance Diagrams
To determine the cooling capacity of an air conditioner under the above-described variable conditions, a performance diagram can be used. These charts show the cooling capacity of an air conditioner per the requirements of DIN 3168, as well as under different temperature scenarios—including maximum operating conditions. This will help users to determine how a particular air conditioner will perform in a specific application.



To read a performance diagram:

1. Locate the vertical line representing the external temperature.
2. Locate the diagonal line representing the internal temperature.
3. At the intersection of the two lines, draw a line to the left to determine the air conditioner's performance at that point.

Air Conditioner Sizing
When selecting an air conditioner, the easiest way to figure out how an air conditioner will perform at given temperatures is to use sizing software. These convenient tools typically walk users through the various factors that impact an application, and then determine the need for cooling. Rittal's Therm 5.14 sizing software, for example, can calculate what the internal enclosure temperature would be without any means of cooling before predicting how many BTU or Watts of cooling capacity the application requires and suggesting an appropriate part number.

Calculating Air Conditioner Efficiency
Reducing power consumption and increasing efficiency are vitally important to protecting the environment, and to saving money during the operation of air conditioners at the end user level. The formula to determine the efficiency of an air conditioner (shown below) is simple—it's the ratio between useful cooling capacity and power consumption. The higher the cooling efficiency factor, the more efficient the air conditioner is.

$$\varepsilon = \frac{\dot{Q}_k}{P_{el}}$$

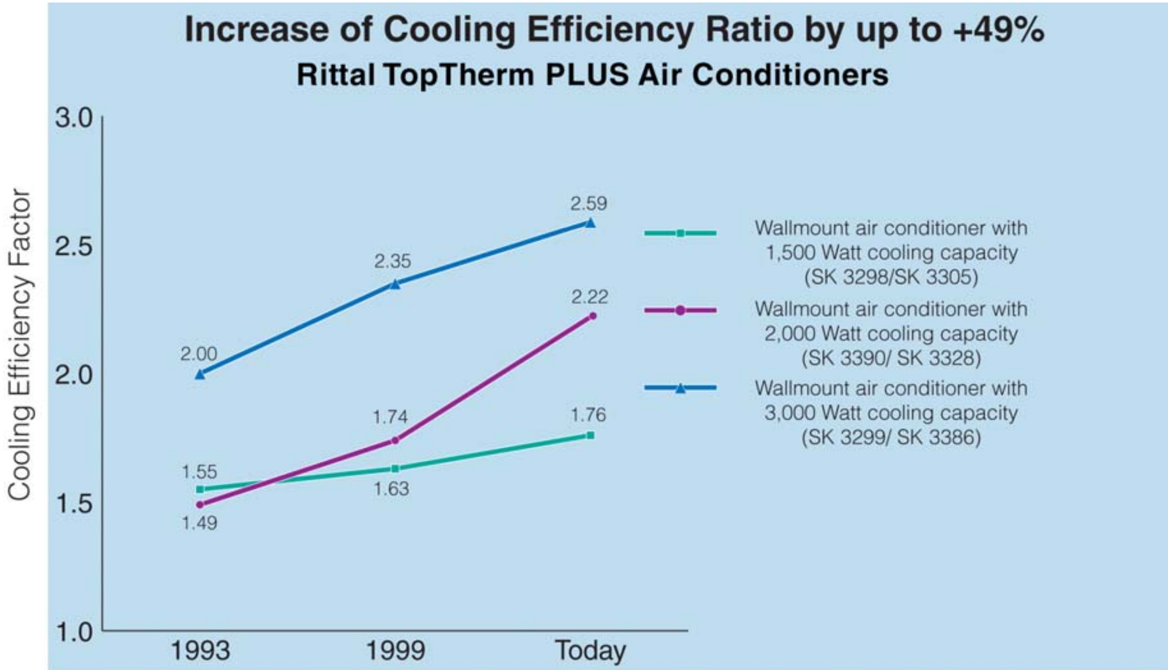
ε = Cooling Efficiency Factor
$\dot{Q}_k$ = Useful Cooling Capacity [W]
P_{el} = Power Consumption [W]

Example:

Enclosure Air Conditioner: 460 V, 60 Hz
Cooling capacity at 95/95, 60 Hz: 2700 Watt
Power consumption at 95/95, 60 Hz: 1500 Watt

Cooling efficiency factor = $\frac{2700 \text{ Watt}}{1500 \text{ Watt}}$

Cooling efficiency factor = 1.8



Calculating the Impact of Humidity

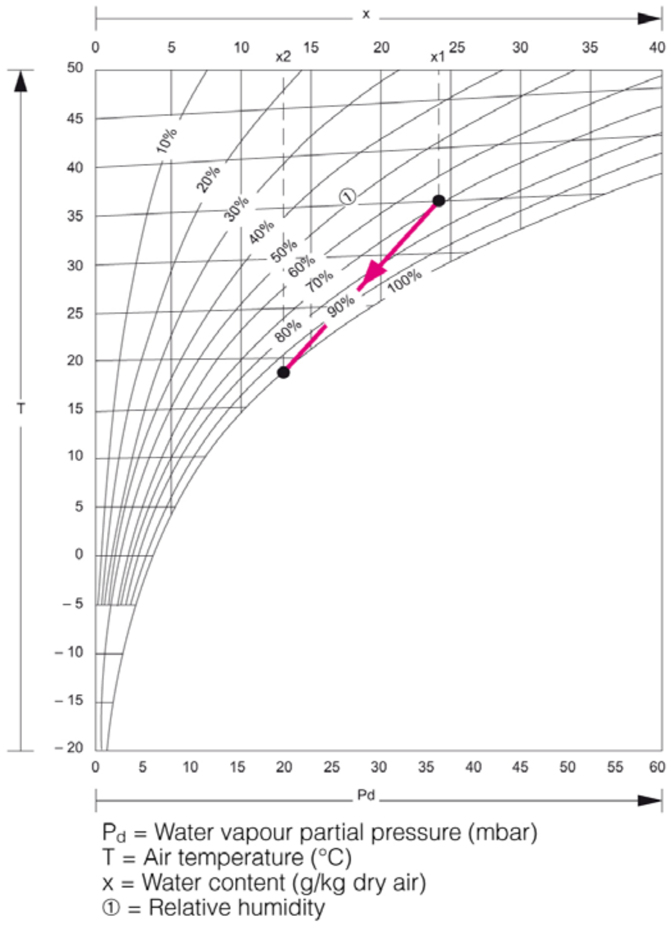
An unavoidable side effect of using air conditioners is the dehumidification of the enclosure's interior air. As it cools down, part of the humidity contained in the air condenses on the evaporator coil. The reliable discharge of this condensate from the enclosure is important to consider, and is achieved by using condensate hoses and collection bottles in conventional units, or via condensate evaporators in more advanced products like Rittal's TopTherm PLUS.

The amount of condensate that is created depends on relative humidity, the air temperature in the enclosure, the evaporator coil, and the air volume present in the enclosure. The Mollier h-x diagram (see next page) is used to show the water content of air depending on its temperature and relative air humidity.

Calculation Example:

An enclosure air conditioner has a temperature set point of Ti = 95° F. The relative ambient air humidity is 70%. If 95° F air is exchanged over the evaporator coil, the surface temperature of the evaporator coil (evaporation temperature of the refrigerant) is approximately 64° F. At the outer layer, adhering to the surface of the evaporator coil, water (condensate) is deposited at the dew point. The difference, $\Delta x = x1 - x2$, indicates the amount of condensation that occurs per 2.2 lb of air with complete dehumidification. How airtight an enclosure is plays an important role in the amount of condensation that will occur in an application. Since the quantity of ambient air (and as a result, the amount of humidity) is limited in a properly sealed enclosure, the amount of condensation will be limited too.

Mollier h-x diagram
for calculating the water content of air.



Application Example Using Mollier h-x Diagram (above):

Equation: W = V · ρ · Δx

where:
W = Water quantity in grams
V = Volume in m^3
ρ = Density of the air in kg/m^3
Δx = Difference in water content in g/kg dry air (from the Mollier h-x diagram)

Enclosure door closed, ambient air is not entering the enclosure—
only the humidity trapped inside of the enclosure is being dehumidified.

V = W · H · D = 0.6 m · 2 m · 0.5 m
V = 0.6 m^3
W = V · ρ · Δx
= 0.6 m^3 · 1.2 kg/m^3 · 11 g/kg
W = 7.92 g 8 ml.

If placed into the same calculation example above, an enclosure that is not properly sealed will see more condensation. Ambient (humid) air can enter through poorly sealed cable entries, damaged or open enclosure doors, and damaged enclosure gaskets—resulting in increased condensation. If, for example, ambient air is entering the enclosure at a rate of 5 m^3/h, a permanent condensation amount of 2.7 oz/h (80ml/h) may occur.

Because of this, it's always recommended that control panels be operated with enclosure doors closed and that all sides of the enclosure are properly sealed and gasketed. In addition, it is advisable to use a door switch that interrupts the operation of the air conditioner while the enclosure door is open and to set the internal temperature of the enclosure only as low as is actually needed.

Conclusions

Selecting the right air conditioner for an industrial enclosure application is crucial to maximizing efficiency, performance, and overall return on investment. Knowing what factors to consider, and taking the time to properly evaluate the products available, can save money by reducing utility costs, drastically improve the life and reliability of installed equipment, and solidify operations as a whole through increased productivity and limiting unplanned downtime.

About the Author

Judith Koetzsch has been with Rittal since 2001—first working for Rittal GmbH & Co. Kg. in Germany as a part of the international climate control product management team, and then joining Rittal Corporation in the U.S. as Product Manager for Climate Control Products in 2006.