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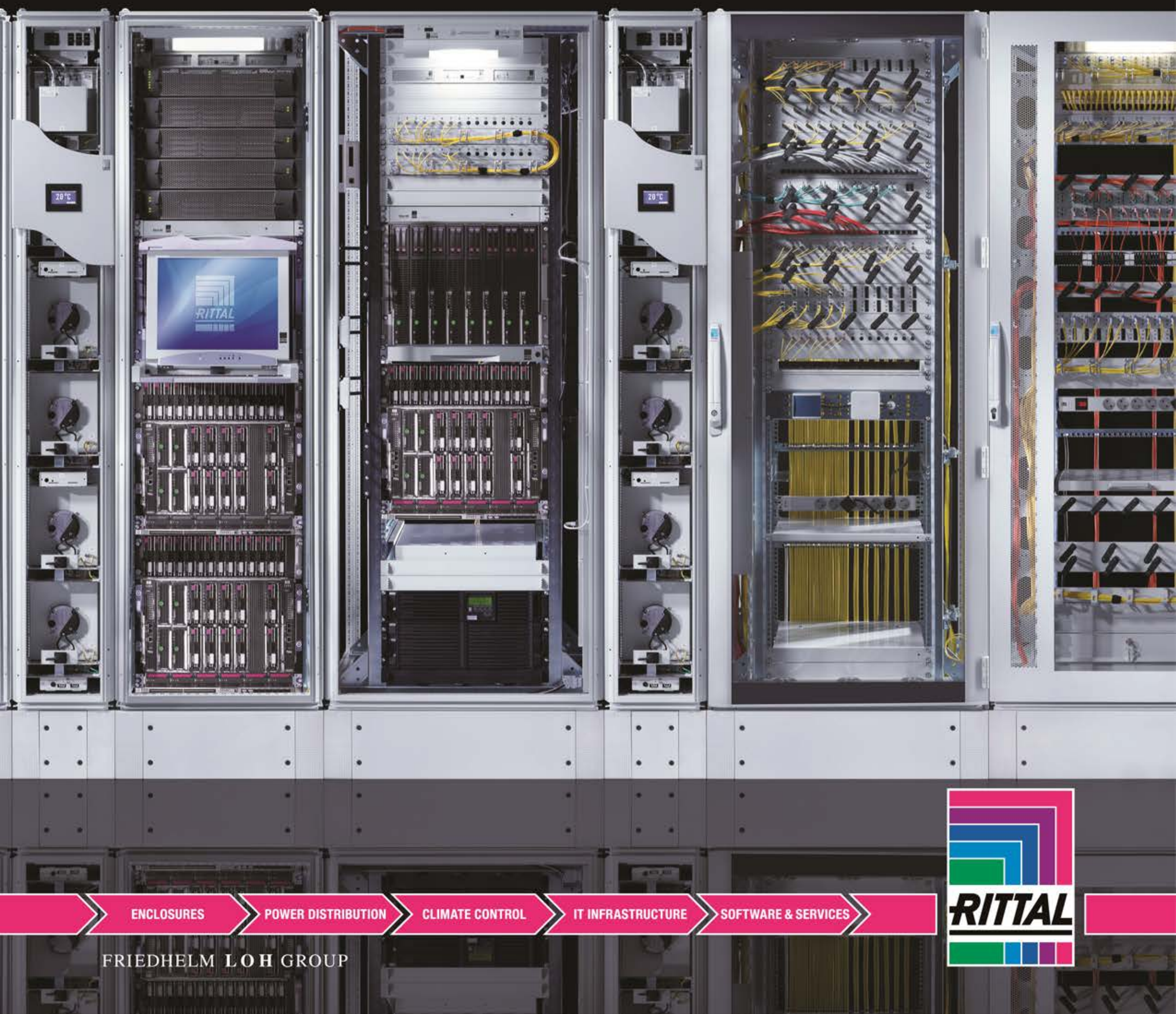
WHITE PAPER: Energy Efficient Enclosure Climate Control



Energy Efficient Enclosure Climate Control

Executive Summary

The modern business environment has transformed energy efficiency from a luxury sought after by so-called “green businesses” into a necessity for all operations that need to find ways to increase energy and cost savings without hurting productivity. Tightening budgets demand that ways be found to do more with less.

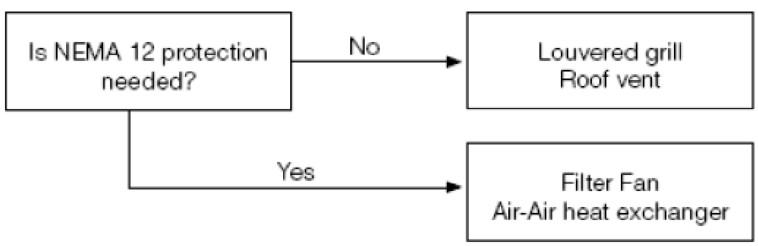
Sophisticated, sensitive electronics and drives are the backbone of many industrial applications and this equipment is often placed inside enclosures to protect it from the rugged environments it is deployed in. Depending on the surrounding temperature and other ambient conditions, it is imperative that these enclosures be cooled to ensure the proper performance of installed components and avoid heat-related downtime. According to the Rocky Mountain Institute, a nonprofit efficiency-focused research organization, in industrial settings, "there are abundant opportunities to save…60% of the energy and cost[s] in areas such as heating [and] cooling..." This white paper will discuss tips for cooling enclosures that can reduce energy consumption and save money.

Design Phase:

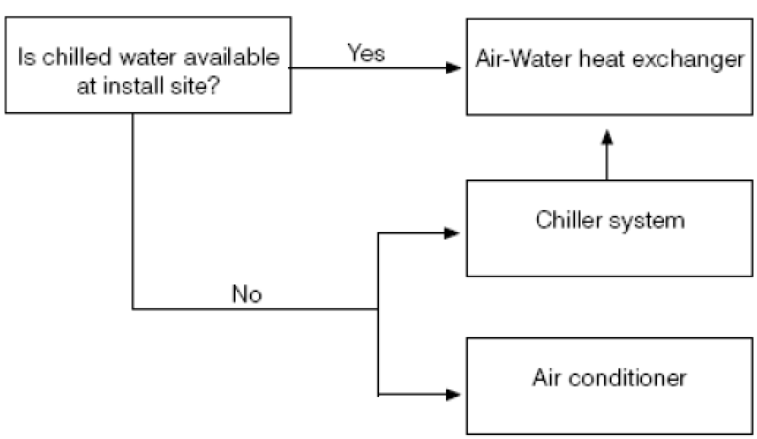
How Much Cooling Is Needed?

The question to ask when attempting to save energy cooling industrial enclosures is simple, “Does this application require cooling, and if so, how much?” It is important to determine the correct amount of cooling to prevent energy from being wasted by cooling components to lower than needed temperatures or even by cooling components that might not need it at all—the most energy efficient cooling device is one that is not needed. To figure out the appropriate climate control solution for a given application, three pieces of information are required: how big is the enclosure? how much heat will be created by installed equipment? and finally, where is the enclosure going to be located? Once known, it’s possible to perform some calculations either manually, or by using a software tool such as Rittal’s *Therm* software. For the purposes of this paper, a manual calculation will be used. The first step to selecting the right climate control solution is to consider the factors listed in the flowchart below to see what types of products may be applicable to a given situation.

Ambient Temperature < Enclosure Temperature



Ambient Temperature > Enclosure Temperature



As stated previously, in order to properly size climate control components, next, the surface area (size) of the enclosure, the ambient (surrounding) temperature and the amount of (installed) heat in the enclosure need to be taken into account.

What does the surface area have to do with the climate control? Without expending any outside energy, heat flows in only one direction—from hot to cold. This phenomenon is why coffee cools down after a few minutes as it sits on a table. The room is cooler than the coffee, so the heat "leaves" the cup and is diffused throughout the entire room. In the case of climate control, it must be determined whether the heat from the surrounding area is going to move into the enclosure or if the heat from the enclosure is going to be dissipated. The surface of the enclosure is where this interaction is takes place, and like the coffee cup, the heat will flow from the sides, top and bottom.

Although it's possible to calculate the surface area by adding up the area of all 4 sides of the enclosure, this may not be exactly where the heat is leaving. For example, if the rear of an enclosure is placed against a wall. By sitting the enclosure against the wall, the wall will heat up in that spot creating a smaller temperature difference between the wall and the enclosure—slowing down or preventing the heat from flowing out of the enclosure. The difference in temperature is what allows the heat to flow, so if there isn't any difference in temperature, there isn't any heat flow. Because of this, it was decided by an international convention (DIN 57 660 part 50 and VDE 660 part 500) to modify the surface area of an enclosure to take this into account (since this was an international convention, the units will be in metric).

Enclosure Installation type to IEC 890

- Single enclosure, free-standing on all sides
- Single enclosure for wall mounting
- First or last enclosure in a suite, free-standing
- First or last enclosure in a suite, for wall-mounting
- Enclosure within a suite, free-standing
- Enclosure within a suite, for wall-mounting
- Enclosure within a suite, for wall-mounting, covered roof surface

Installation type to IEC 890	Formula for calculating A [ft²]	
□	A = 1.8 x H X (W + D)	+ 1.4 x W x D
□	A = 1.4 x W x (H + D)	+ 1.8 x D x H
□	A = 1.4 x D x (H + W)	+ 1.8 x W x H
□	A = 1.4 x H x (W + D)	+ 1.4 x W x D
□	A = 1.8 x W x H	+ 1.4 x W x D + D x H
□	A = 1.4 x W x (H + D)	+ D x H
▨	A = 1.4 x W x H	+ 0.7 x W x D + D x H

A = Effective enclosure surface area
W = Enclosure width
H = Enclosure height
D = Enclosure depth

Installed Heat

Once the surface area of the enclosure is found, it is possible to calculate the heat "contained" within it by using the temperature difference between the interior of the enclosure and the surrounding, exterior environment (for a previously completed system), or by adding up the total heat loss from installed components utilizing information found on their respective data sheets (primarily when configuring a new system).

Heat Calculation for a Previously Completed System

$$Qe = Qv - A \times k \times \Delta T$$

Where
Qv is the amount heat from the components inside the enclosure
A is the effective surface area from calculation above
K is 5.5 w/m_2 Celsius (sheet steel, different numbers for different materials)
Δ T is the temperature difference T_a-T_i in Celsius

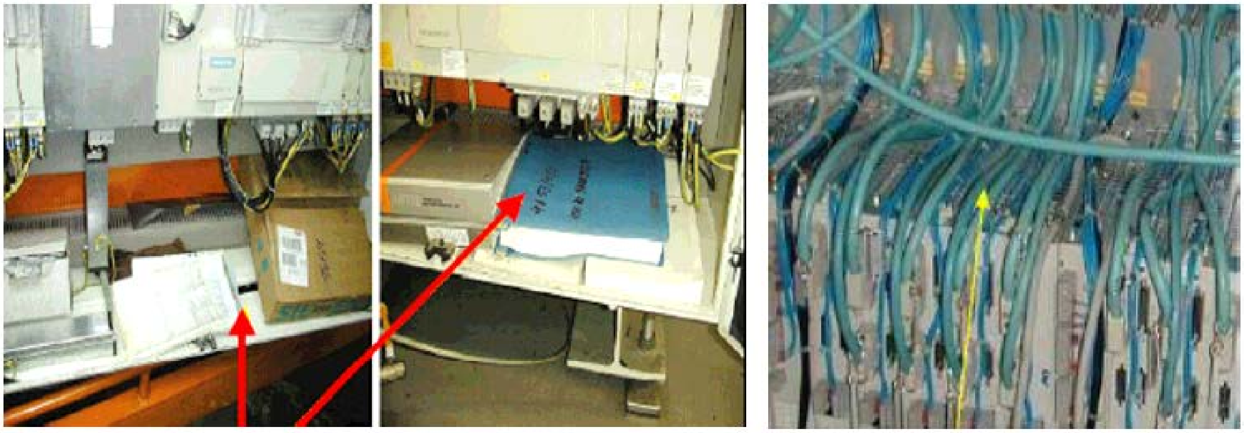
After this calculation is completed and the amount of heat installed inside the enclosure is determined, if a need for climate control exists, the process of selecting the correct solution can begin in earnest. There are a variety of common solutions to suit different requirements including filter fans, air-to-air heat exchangers, air conditioners or air-to-water heat exchangers—each with distinct strengths and benefits. From an energy efficiency standpoint, filter fans and air-to-air heat exchangers will use less energy but require an ambient temperature below that of the desired internal enclosure temperature to be effective. If cooling to temperatures below ambient conditions is necessary, an air conditioner or air-to-water heat exchanger is required.

Proper selection of a climate control device is an important starting point for maximizing the energy efficiency of an application, but other factors like its placement on the enclosure and relative to its surroundings (both internal and external), along with general maintenance can also lead to a significant increase in efficiency.

Installation Phase:

Mounting Components Inside and Outside Enclosures

When mounting components, including climate control, on or inside enclosures, it is important to leave enough space for the climate control to work effectively.



In the examples shown above there are cables, books, spare parts and other objects blocking the airflow of the components installed inside the enclosures. Because of this, these components will not be cooled effectively and the possibility that their lifespans could be shortened or that they will experience heat-related failures is drastically increased. It is vitally important to allow components enough free space to encourage air movement. The pictures below demonstrate how cables and obstructions can be removed to provide adequate airflow inside an enclosure.

In addition to ensuring that there is plenty of space for air to circulate within an enclosure, another common problem that can hamper efficiency is climate control that doesn't have enough room to "breathe." Generally speaking, to prevent this, installed components should be spaced no less than 8" away from the incoming air generated by climate control products and component fans should not blow against the fans of a cooling unit as this may cause a short circuit. To allow for optimum airflow for climate control units in relation to possible hindrances outside of the enclosure, it is best to keep at least 8-16" between surrounding objects and the climate control device to provide adequate airflow.

Installing climate control properly on the enclosure is important for effective operation. Unless otherwise required by the demands of an application, it is normally recommended that filter fans be placed at the bottom of an enclosure with the corresponding exhaust filter installed at the top of the opposite side. This way, the fan can draw in the cooler air located near the floor and a cross-ventilation is created inside the enclosure for increased heat removal. Air conditioners and heat exchangers can be mounted either on the walls or roof of an enclosure and should be installed per the manufacturer's instructions for best results.

Another way to aid the performance of climate control equipment is in the planning stages of enclosure placement. Keeping the enclosure far enough away from any heat sources prevents excessive heating and possible damage.



Proper sizing and efficient deployment are easy ways to get the highest returns from industrial climate control products, but maximizing efficiency doesn't stop there. Maintaining the units over the course of their service life will keep performance levels up and energy usage down.

Operation Phase:

Efficiency in Operation—Filter Fans and Air Conditioners

Maintaining filter fans is relatively simple because it's usually possible, with a glance, to determine if the filter media is clogged or dirty and needs to be changed. While this may sound rudimentary, this is an important step for the fan to work effectively. Regular maintenance is required for air conditioners as well, although the areas of concern may not be quite as apparent. In order to understand what general maintenance is required, we need to take a simplified look at how air conditioners operate.

There are two different sides to an air conditioner—hot and cold. The "hot" side is the outside of the air conditioner and the "cold" side is the internal side. There are copper coils located on both sides, the condenser coil externally and the evaporator coil internally. Refrigerant moves back and forth inside these copper coils and transfers the heat from the inside of the enclosure to the outside. To circulate the air treated by the coils, fans blow across them, making it problematic if the coils become blocked or clogged-up with contaminants because the airflow is reduced and the air conditioner becomes less efficient—working harder and harder, using more energy, but producing less actual cooling output.

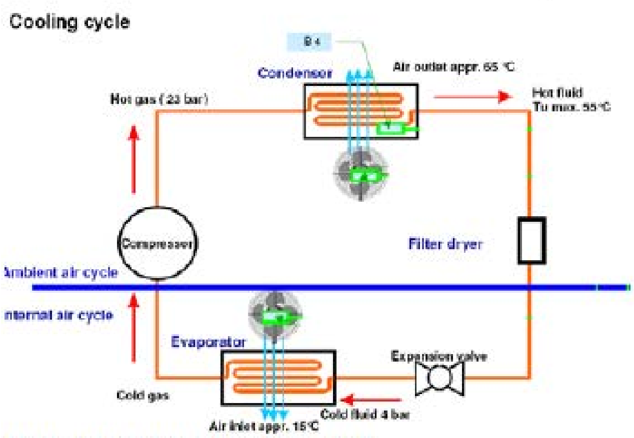


Diagram of a typical cooling circuit.


Clogged condenser coil.

In order to prevent the condenser coil from becoming clogged, the coil itself can be treated with a protective substance like Rittal's RiNano coating that prevents dirt, oil and other contaminants from sticking to it, or a filter can be installed to catch environmental particulates before they reach the coil at all. If a filter is used, appropriate cleaning and replacement frequency will be dependent upon the environment that the air conditioner operates in. There are 3 common types of filters and each is designed specifically for different environments. Metal filters excel in oily environments, lint filters (as the name implies) are intended for settings where there's an abundance of lint in the air and lastly, foam filters are effective for applications in exceptionally dusty environments. As with most devices, air conditioners and filter fans may need general required maintenance to ensure consistently high levels of performance and efficiency.

Air-to-Water Heater Exchangers and Energy Efficiency

Air-to-water heat exchangers can be used in harsher environments than filter fans and can cool the components inside an enclosure to temperatures below ambient conditions like air conditioners. Air-to-water heat exchangers operate in conjunction with a chilled water supply. The chilled water runs through a coil inside the heat exchanger and an internal fan blows air across the coil. Heat is transferred from inside the enclosure to the water, which absorbs it and then carries it away to the chiller where the water is cooled and then re-circulated.

Air-to-water heat exchangers require very little energy to operate and are considered to be a low-maintenance, highly efficient climate control solution. Air-to-water heat exchangers require a chilled water supply to function, and fortunately, many industrial factories have this readily available for use in cooling industrial processes such as metal and plastic forming. Industrial chiller systems are generally large in scale and vital to plant operations. These large systems are intrinsically efficient because of the economy of scale principle and generally speaking, the larger a system is, the more efficient it is.

To get the most effective and efficient cooling from a chilled water system, the pipes used in the piping system should be insulated and not allowed to linger in extremely hot areas. It is also important to install the chiller itself in a location that doesn’t expose it to excessive heat such as near ovens or furnaces.

Air Conditioners and the Cooling Coefficient

To precisely select an air conditioner of the correct size and optimum efficiency for an application it is necessary to consider the amount of heat that must be removed from the enclosure and how much energy it takes to do it.

For residential air conditioning systems, this determination is made using the SEER (Seasonal Energy Efficiency Ratio) rating. Unlike the units found in residential settings, industrial air conditioners typically operate year-round and 24 hours a day since the components in an enclosure are producing heat whenever the equipment is running. In the case of industrial air conditioners, a similar measure of efficiency is the Cooling Coefficient which is a ratio calculated by dividing the amount of cooling capacity by the amount of power consumption. This calculation is made at a particular internal and ambient temperature (typically 95° F internally and externally). The ratings will change at different temperatures and allow users to compare manufacturers of similar equipment by evaluating efficiency by the same standard.

Conclusions

Creating effective and energy efficient climate control solutions for industrial applications consists of 3 key phases—design, installation and operation.

During the design phase, the overall panel layout, heat calculations and climate control selection should be completed. When laying out the panel, care should be taken to ensure adequate airflow within the enclosure. Determining the amount of cooling that will be needed, as well as what type of environment the enclosure will be deployed in are crucial factors to selecting the type and size of cooling solution that will deliver the performance and efficiency required for the job.

The design phase will, in part, develop a large portion of the installation plan simply by virtue of its results. Attention to detail is crucial at this stage and care must be taken to properly install the components and climate control products in accordance with the design plan to achieve the project goals for efficiency and effectiveness. Checking for proper enclosure seals and other possible trouble spots that could jeopardize the success of the application is recommended at this point.

Once operational, climate control devices and other components should be monitored for performance and regular maintenance should be performed to extend the life of integrated parts and keep energy efficiency as close to desired levels as lpossible.

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