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WHITE PAPER: Selecting and Operating Energy-Efficient Climate Products for Industrial Enclosures

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Selecting and Operating Energy-Efficient Climate Products for Industrial Enclosures

Contributed by Rittal North America LLC, this whitepaper describes that effective and energy-efficient climate control solutions for industrial applications consist of three key phases—design, installation, and operation.

Executive Summary

The modern business environment has transformed energy efficiency from a luxury sought after by so-called 'green enterprises' into a necessity for all operations needing to find ways to increase cost savings without hurting productivity. Tightening budgets demand ways are 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 harsh environments it is deployed in. Depending on the surrounding temperature and other ambient conditions, it is imperative 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 per cent of the energy and cost[s] in areas such as heating [and] cooling..."

Creating an effective climate control solution for industrial applications consist of three key phases—design, installation, and operation. No one phase more important than the next, but when combined will provide years of service life with the most economical total cost of ownership (TCO).

Which climate product is needed?

There are many different types of climate products each with a distinct advantage for a specific application. Filter fans and air-to-air heat exchangers use less electricity, but require an ambient temperature below that of the desired internal enclosure temperature. If cooling to temperatures below ambient conditions is necessary, an air conditioner or air-to-water heat exchanger is required.

As an example, we will use a 2000 mm X 800 mm X 600 mm carbon steel enclosure housing seven variable frequency drives that is to be installed in a manufacturing setting with a maximum ambient temperature of 40^0 C while maintaining an internal enclosure temperature of 35 ^{0}C.

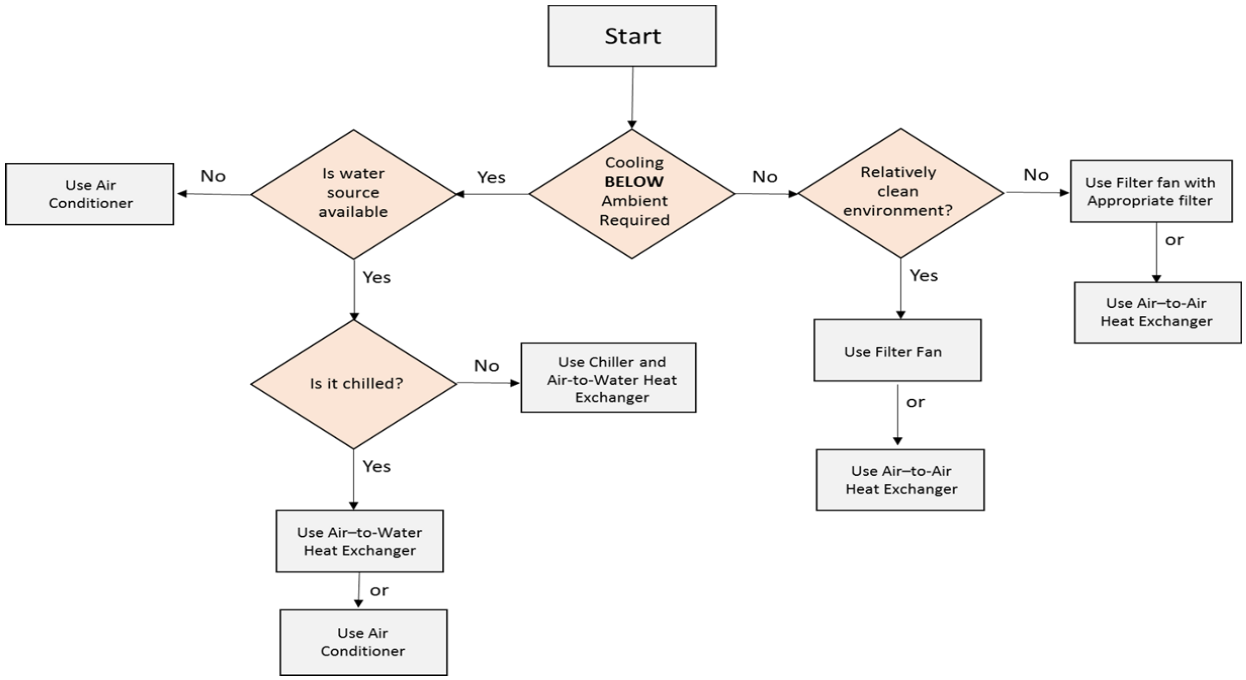

Figure 1

Using the simple decision tree above, we have determined it will require cooling below ambient temperature and there is not a chilled water source. Thus, an air conditioner will be used in this application.

How much cooling is required?
It is important to ensure the enclosure is adequately cooled while preventing energy waste by cooling components lower than needed. Three pieces of information are needed to determine the appropriate cooling capacity for a given application:

- Size [Surface Area] of enclosure
- Method enclosure will be installed
- Total thermal load of installed equipment

NOTE: This may be done with computational fluid dynamic, CFD, software. Or we can use Rittal's Therm climate software which is offered as a free download from www.rittal-corp.com/software. However, we will work through it manually to fully understand why this data is needed.

The Second Law of Thermodynamics states that heat transfer occurs spontaneously only from higher to lower temperature bodies You can see this proven each morning when your coffee cools down after a few minutes on a table. The room is cooler than the coffee, so the heat ‘leaves’ the cup and is diffused throughout the room. In the case of an enclosure, it must be determined whether the heat from the surrounding area is going to be absorbed by the enclosure surface (Tu > Ti) or if the heat from within the enclosure will be dissipated through the walls into the ambient environment (Ti > Tu). This takes place on all surfaces of the enclosure--the sides, top, and bottom.

Knowing the method in which the enclosure will be installed is a crucial for accurate surface area calculations. Although it appears all that is needed to calculate the surface area is summing the enclosure walls, top, and bottom areas this is not accurate. Consider if the enclosure is installed against a wall. (*Figure 2*) In this method, the heat energy will not transfer uniformly on each side; the enclosure will either absorb more external heat energy or dissipate less where the enclosure is in close proximity to the wall. Thus, one must calculate the EFFECTIVE surface area depending on the type of installation.

The method of installation of the enclosure changes the effective surface area.

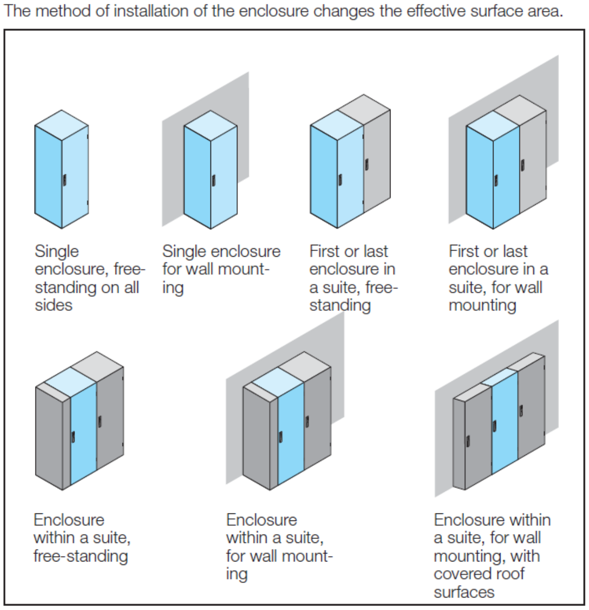

Figure 2

	Enclosure installation type according to IEC 60 890
	Single enclosure, free-standing on all sides $A = 1.8 \cdot H \cdot (W + D) + 1.4 \cdot W \cdot D$
	Single enclosure for wall mounting $A = 1.4 \cdot W \cdot (H + D) + 1.8 \cdot H \cdot D$
	First or last enclosure in a suite, free-standing $A = 1.4 \cdot D \cdot (W + H) + 1.8 \cdot W \cdot H$
	First or last enclosure in a suite, for wall mounting $A = 1.4 \cdot H \cdot (W + D) + 1.4 \cdot W \cdot D$
	Enclosure within a suite, free-standing $A = 1.8 \cdot W \cdot H + 1.4 \cdot W \cdot D + H \cdot D$
	Enclosure within a suite, for wall mounting $A = 1.4 \cdot W \cdot (H + D) + H \cdot D$
	Enclosure within a suite, for wall mounting, covered roof surfaces $A = 1.4 \cdot W \cdot H + 0.7 \cdot W \cdot D + H \cdot D$

A = Effective enclosure surface area [m^2]
W = Enclosure width [m]
H = Enclosure height [m]
D = Enclosure depth [m]

According to VDE* Standard 0660 Part 500 the formula to find effective surface area is:

$$A = 1.4 * W * (H + D) + 1.8 * H * D$$

Using our example enclosure of 2000 mm X 800 mm X 600 mm results:

$$A = 1.4 * 0.800 * (2.00 + 0.600) + 1.8 * 2.00 * 0.600$$
$$A = 5.072 \text{ m2}$$

Enclosure Thermal Load

Once the effective surface area of the enclosure is found, it is possible to calculate the heat loss within the enclosure that must be removed. It must be determined what heat-generating equipment is installed and the aggregate thermal footprint. A good rule of thumb is if the item requires electricity to function, e.g., variable frequency drive, motion control, etc., it will have energy loss in the form of heat. However, if the device does not require electricity to operate, e.g., circuit breaker, disconnect, etc., they will not typically have energy loss that must be accounted for when calculating. The easiest way to find a device's heat loss is to visit the manufacturer's website where this is often listed as its efficiency rating. Once you have this for each component, add them up to determine your total heat loss.

The formula to calculate total thermal load to be removed from an enclosure (Qe) is:

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

Where Qv is the amount heat loss from the installed components. In our example, we have seven variable frequency drives with an aggregate heat loss of 1500 Watts. (Qv = 1500W). A is the effective surface area (calculated above: 5.072 m2); K is the heat transfer coefficient based on enclosure material. We are using steel which is 5.5 W/m2 K. ΔT is the temperature delta between the internal temperature (Ti) and the maximum ambient temperature, (Tu).

$$Qe = 1500W - 5.072 \text{ m2} \times 5.5 \text{ W/m2 K} \times (35^0 \text{ C} - 40^0 \text{ C})$$
$$Qe = 1{,}639W$$

Based on above calculations, this application requires an air conditioner that provides at least 1,639W of cooling.

**VDE is the acronym from Verband der Elektrotechnik now known as the Association for Electrical, Electronic & Information Technologies. The VDE Testing and Certification Institute is accredited for the testing and certification of electrical components and systems.*

Installation phase

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 in *Figure 3*, cables, books, spare parts, and other objects block the airflow of the components installed inside the enclosures. This does not allow the climate solution to “breathe.” To prevent this, installed components should be spaced no less than 203 mm (8 in.) away from climate control products.

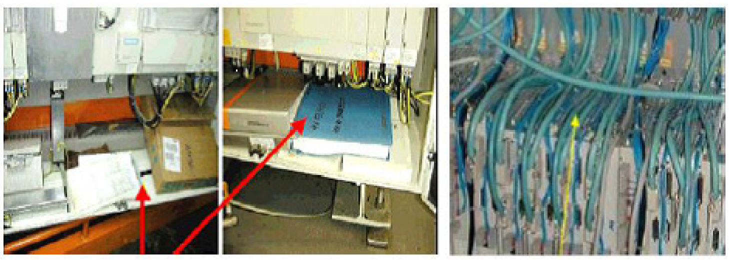

Figure 3

Figure 4

Additionally, as shown in *Figure 4*, external obstructions may be an issue. As shown in this picture, the installed devices will not be cooled effectively and the possibility of shortened lifespans or heat-related failures increases. It is important to provide an adequate amount of space around enclosures to promote dissipation of heat energy and proper air movement. 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 203 to 406 mm (8 to 16 in.) between surrounding objects and the climate control device. Also, access to the unit for future maintenance must be considered.

Figure 5

Installing climate control properly on the enclosure is important for effective operation (*Figure 5*). Unless required by the demands of an application, it is recommended 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.

Operational phase

Although correct sizing and proper installation are essential to getting the highest returns from indus¬trial climate control products, maximizing efficiency doesn't stop there. Maintaining the units over the course of their useful life will keep performance levels up and energy usage down

The primary factor associated with reducing airflow or cooling capacity and efficiency is dust, dirt, and/or oil collecting on the unit. If this happens, the climate product does not function as designed, which greatly increases the chance of a catastrophic failure; not only of the cooling unit but the components within the enclosure as well. Thus, a regular maintenance schedule based on the specific environmental factors is essential.

Conclusion

During the design phase, the overall panel layout, climate control selection, and heat calculations should be completed with the utmost care. When laying out the panel, ensure there is 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 essential factors to selecting the type and size of cooling solution that will provide the proper cooling profile.

The design phase will, in part, develop a large portion of the installation plan simply by virtue of its results. Attention to detail is a must 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.

As with any mechanical system, the climate system must be properly maintained. Once operational, climate control products should be monitored for performance, a regular maintenance schedule should be established in accordance with manufacturer's guidelines to ensure optimum performance of the unit. The practice will not only ensure the longest service life possible for the climate product, but all the installed components.

Following these simple steps outlined here will simplify choosing the correct climate product with highest efficiencies for the application and provide the longest lifespan—not only for the chosen climate control product—but the electrical/electronic components installed within the enclosure as well.

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