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Enclosure Climate Control Cooling Unit Selection

to Maximize Efficiency, Performance and Productivity

The issue of climate control is frequently neglected when designing an enclosure. However, choosing the right cooling device is crucial in maximizing the efficiency, performance and productivity of a unit. This white paper explains how you can make the right choice.

White Paper
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Introduction

Selecting the right cooling unit for an industrial enclosure has a major impact on the performance and efficiency of the entire industrial process. Suitable and efficient cooling devices significantly extend the service life of the components installed, because they are energy-efficient and prevent unplanned downtime. Although cooling is sometimes neglected when designing enclosures, given the correct selection information and the right application considerations, a cooling unit can make a positive contribution to increased productivity and profitability. In this white paper, we highlight all factors that are crucial when choosing a cooling unit for an enclosure, such as function, internal heat load, calculation of the required performance, the influence of humidity and other environmental conditions and, of course, energy efficiency.

The job of the cooling unit is to dissipate the heat generated in the enclosure as efficiently as possible and to cool the air in the enclosure to protect temperature-sensitive components. The device is installed on the side, at the rear or in the door of an enclosure.

Purpose of a cooling unit

The cooling unit (compressor refrigerating machine) comprises four main components (see Fig. 1): The evaporator (7), compressor (10), condenser (1) and the control valve or expansion valve (5), which are all connected by piping. This circuit is filled by a substance with a low boiling point, the coolant.

Function of the cooling unit

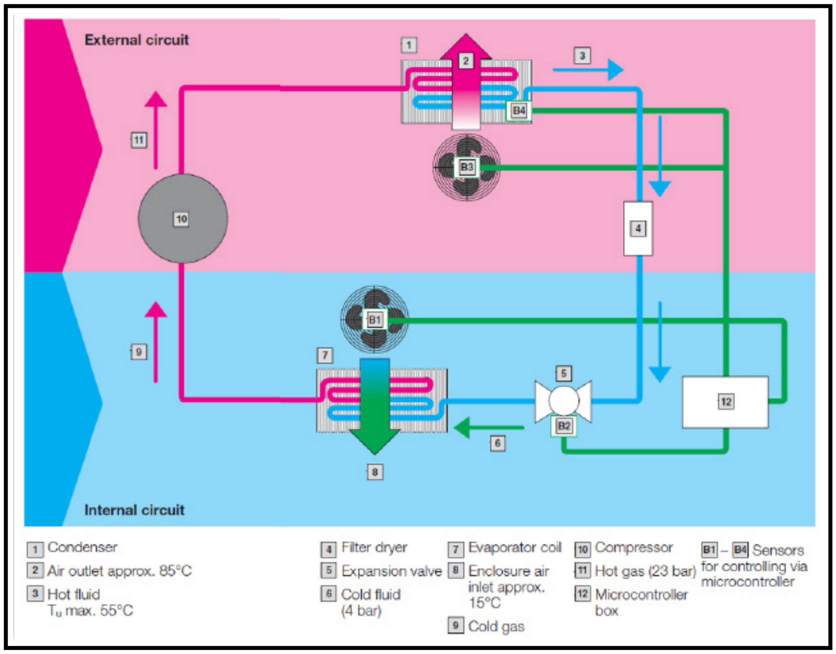


Fig. 1 Cooling circuit

The refrigerant R134a (CH_2FCF_3) is free from chlorine; its ozone depletion potential is 0. This refrigerant is therefore environmentally friendly. The filter dryer (4) integrated into the closed cooling circuit binds any residual moisture and dirt particles contained in the system and offers effective protection against corrosion in the cooling circuit.

The liquid coolant is transformed into a gaseous state in the evaporator (7). The energy required to do this is extracted from the air in the enclosure as heat, and thus provides cooling. The gaseous refrigerant is compressed in the compressor (10). It heats up and reaches a higher temperature inside the condenser (1) than the ambient air. The excess heat can now be discharged to the ambient air via the surface of the condenser. As a result, the refrigerant cools and changes its physical state from gaseous to liquid. The still liquid refrigerant is injected back into the evaporator via a thermostatic expansion valve (5). As a result of the expansion or the pressure drop, the temperature of the refrigerant drops even further so that it can once more absorb energy from the air in the interior of the enclosure, evaporating in the process. The cycle then starts again from the beginning.

Internal heat load

The internal heat load is the energy that the components give off to the enclosure as heat. This amount of heat varies depending on the component and is detailed by the manufacturer of the components in the product specification. The heat load is also referred to as the heat loss. In order to determine the total thermal load of an enclosure, the individual heat losses of all the components must be added together. In the world of electronics, the heat loss (power dissipation) is usually stated in watts, but in America and occasionally in the United Kingdom, BTU/h (British Thermal Unit) is also found, where 1 BTU/h corresponds to 0.29307107 W/h

Calculating the necessary cooling output

Before we can calculate the cooling output required, we need to be aware of a few points:

- Maximum ambient temperature
- Maximum internal temperature
- Dimensions of the enclosure
- Installation of the enclosure in accordance with IEC 890

When we have this data, we can calculate the convection using the following formula:
$Pc = k \times A \times \Delta T$

If the convection is positive, it is called radiation. This applies if the ambient temperature is lower than the desired enclosure temperature. When the convection is negative, we speak of irradiation. This applies if the ambient temperature is higher than the desired enclosure temperature.

Now that we know how high the convection is, we can calculate the total thermal load (heat loss), as well as the necessary cooling output. To do this, we use the following formula:

Pn = Pt - Pc (required cooling output = total thermal load - convection)
Caution: Convection can also be negative

Example calculation
An enclosure made of carbon steel with the dimensions of 2000 x 800 x 800 mm (HxWxD) is positioned against a wall, but it is free on the left and right-hand sides. There is a controller inside the enclosure that generates a total of 750 watts of heat. The enclosure is installed in a room where it can get up to +35 °C in summer. The components in the enclosure have an operating temperature of approx. +45 °C.

Step 1 (Determining the natural convection)
Pc = k x A x ∆T → Pc = 5.5 x 6 x 10 = 330 watts.

Step 2 (Determining the power to be dissipated)
Pn = Pt - Pc → Pn = 1400 - 330 = 1070 watts.

In this example, therefore, a cooling unit with at least 1070 watts must be selected to keep the enclosure at its operating temperature of +45 °C.

Selecting a suitable cooling unit

When choosing a cooling unit, some points need to be considered, such as the ambient temperature, the internal enclosure temperature, and the voltage and frequency.

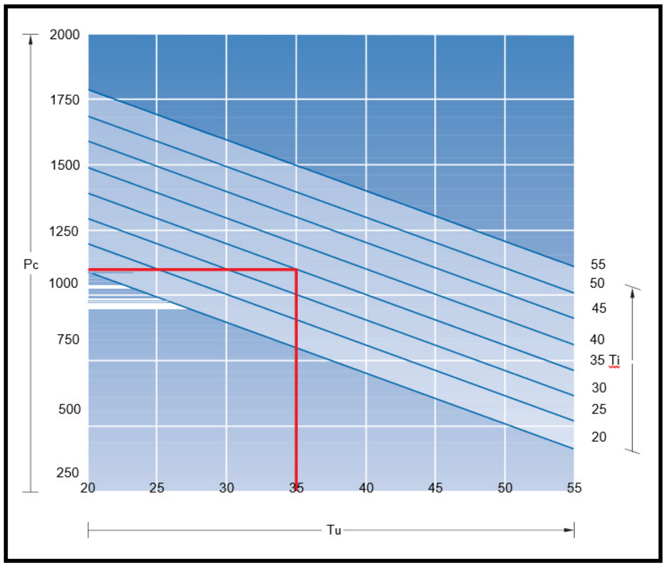
The ambient temperature is a very important factor for the performance of a cooling unit. As the ambient temperature rises, the cooling output decreases, while the energy consumption increases. The power diagram of the SK 3304.500 cooling unit shows that the power at Tu= 35 °C and a desired enclosure temperature of Ti = 35 °C is approximately 1100 watts. If the ambient temperature rises to Tu=50 °C, the output will drop to 910 watts.

The desired internal temperature of the enclosure also has an influence on the output; thus, at a higher desired internal temperature Ti of the enclosure, the cooling unit's output will increase, and the output will decrease when the desired temperature Ti is reduced. In the above example calculation (where Tu = 35 °C and Ti = 45 °C.), the cooling unit has an output of 1,227 watts and is thus of an adequately size.

50 Hz

SK 3304.500, .510, .600, .504

Performance diagram



Tu = ambient temperature (˚C)
Pc = total cooling output (W)
Ti = Internal temperature of the enclosure (in °C)

In most countries, a frequency of 50 Hz is used though there are also some countries where a frequency of 60 Hz is normal. This usually is not a problem for a cooling unit, but be sure to check whether the device selected is suitable for the frequency used. The frequency also affects the performance of the cooling unit. At a frequency of 60 Hz, the compressor and the fan-and-filter units will run more quickly, so that the output will increase. This is normally stated in the specifications. However, this does not apply to cooling units that use inverter technology, as the speed of the compressor and the fan-and-filter units is determined by the inverter control.

Dehumidification

The use of a cooling unit not only cools the air within the enclosure, but it has an additional advantage that, it also dehumidifies it. But exactly how much moisture is extracted from the air inside the enclosure? This can be determined with the help of the Mollier h-x diagram (see figure 2). The cooling unit is put into operation at an air temperature of Ti = +35 °C and a relative humidity of 70%. When air at +35 °C flows over the evaporator at an average evaporation temperature of approx. +18 °C, it meets the cold surface and cools down to below the dew point, whereby condensation forms. The difference $\Delta x = x1 - x2$ shows how much condensation is incurred per kg of air with complete dehumidification. The amount of condensed water is calculated using the following equation:

$W = V \times \rho \times \Delta x$

W = condensate volume; V = volume (WxHxD)

ρ = Density of air = 1.2 kg/m$_3$

Δx = Difference of the water content in g/kg dry air (from the Mollier h-x diagram)

The amount of condensate extracted is shown in this example:

$V = 0.8 \times 2 \times 0.8 = 1.28$ m$_3$

$W = 1.28 \times 1.2 \times 11$ g/kg

$W = 16.90$ g ≈ 17 ml.

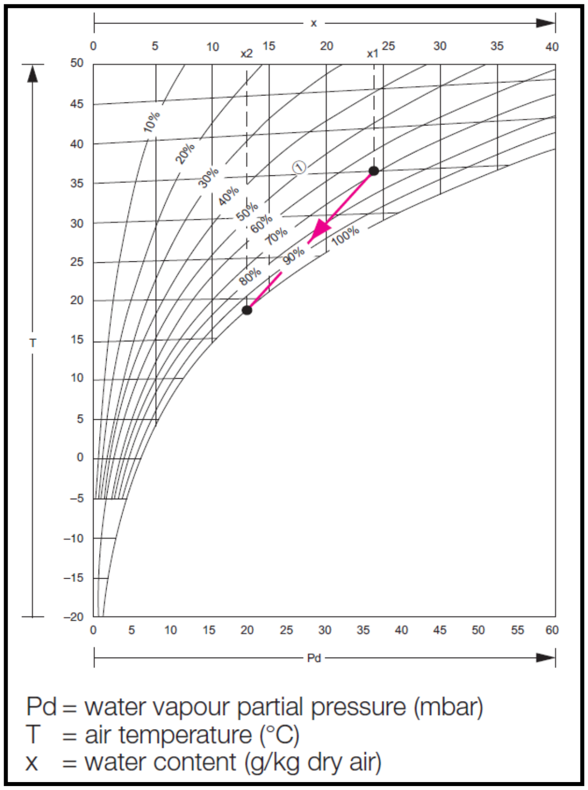


Fig. 2 Mollier h-x diagram

Energy efficiency

Nowadays, there are several developments that make the use of a cooling unit attractive, including reducing the cooling unit’s energy consumption. For example, the introduction of inverter control can be seen, in which the speed of the compressor and the fan-and-filter units is regulated based on the heat load in the enclosure. Another advantage of inverter technology is that the temperature in the enclosure is highly constant, ensuring “stress-free” operation of the components, which leads to a longer service life. Another technology we can observe is the heat pipe. This is a passive method of dissipating heat from the enclosure to the environment. The requirement here is that the environmental temperature is lower than the maximum permissible temperature inside the enclosure. A cooling unit’s efficiency is indicated by the EER (Energy Efficiency Ratio), which can be found in the device’s specifications. This value represents the ratio between the cooling output and the electrical energy required for cooling. The higher this value, the more energy-efficient the cooling unit is.

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Conclusion

In order to ensure the reliability and long service life of your system, the heat generated from the enclosure must be dissipated as efficiently as possible. A cooling unit is the perfect solution for this. It is important that this cooling unit is of sufficient size and has the highest possible EER. This not only increases the system availability, but also results in lower energy consumption and reducing CO_2 emissions. This cuts costs for the operator, therefore saving money.

Sources

Rittal technology library “Enclosure and process cooling”

Therm software

White Paper: “Are you looking for the perfect climate for your enclosure.”

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