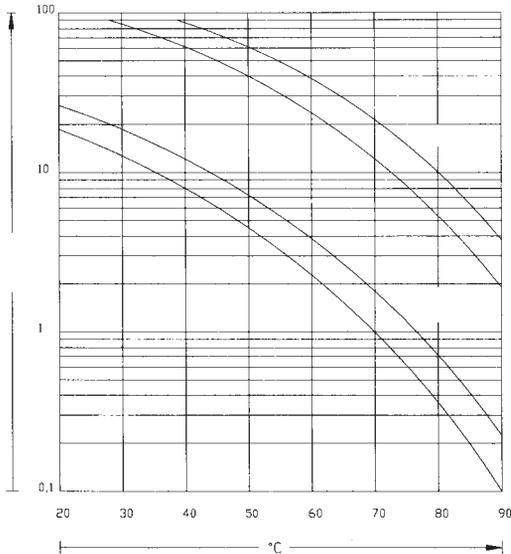


Ever since components have been made to control electro-technical tasks, heat loss has been a subject to take into consideration. Sometimes more—sometimes less.

Major problems with heat caused excessive dust accumulation in switchgear equipment because the doors were left open during the summer to allow the equipment to cool down. This can result in fluctuations in temperature. These lead to stress situations that can considerably reduce the service life of electronic components (see chart).



This chart demonstrates the relationship between temperature and service life.

THREE BASIC COOLING METHODS

When selecting a cooling method there are three types to consider:

- 1. Natural Convection** — If there is only a minimal heat gain in your circumstance, use of louvers or grilles with filters can be effective. This method, however, usually provides less cooling effect than is necessary with today's components (Fig. 1, pg. L15).
- 2. Forced Convection Air Cooling** — If the installation will be in a clean, non-hazardous environment with an acceptable ambient (outside the enclosure) temperature range, a simple forced-air cooling system utilizing outside air is usually adequate. Combined with an air filter, such devices generally meet the heat removal needs of typical electronic equipment and many electrical applications (Fig. 2a & 2b, pg. L16). Examples of forced convection air cooling are Filterfans™ and Box Fans.
- 3. Closed-Loop Cooling** — In harsh environments involving high temperatures, wash-down requirements, heavy particulate matter or the presence of chemicals capable of damaging components (NEMA 4 or 12 environments), ambient air must be kept out of the enclosure. Closed-loop cooling consists of two separate

circulation systems. One system seals out the ambient air, cooling and recirculating clean, cool air throughout the enclosure. The second system uses ambient air or water to remove and discharge the heat (Fig. 3, pg. L18). Examples of closed-loop cooling equipment employed with electronics and process controls are air conditioners and heat exchangers.

Heat Abduction by Natural Convection

If the ambient temperature is lower than the temperature inside the switch cabinet, the dissipated heat escapes into the atmosphere through the surface of the switch cabinet. The following simple equation is used to calculate the level of heat radiated from a switch cabinet:

$$PR[W] = c \times A \times \Delta T$$

P_R[Watt]: Radiation Power

Thermal power radiated from the surface area of the switch cabinet into the ambience or radiated from the ambience into the switch cabinet.

C[W/m²K]: Coefficient of heat transmission

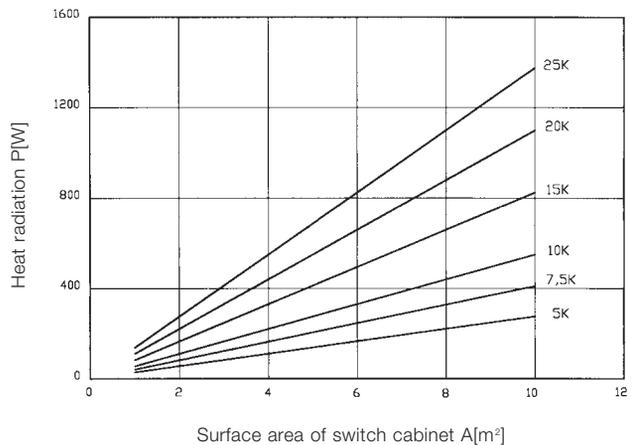
Radiation power per 1m² surface area and 1K difference in temperature. This constant is determined by the material:

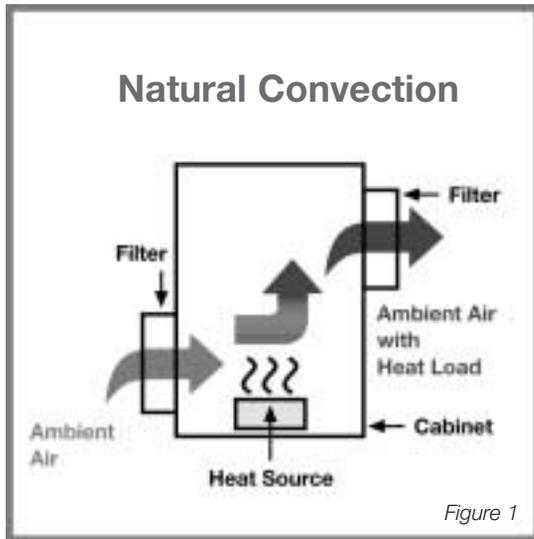
Sheet steel	-5.5 W/m ² K
Stainless steel	-3.7 W/m ² K
Aluminum	-12.0 W/m ² K
Plastic	-0.2 W/m ² K

A[m²]: Surface area of switch cabinet

Effective surface area of a switch cabinet measured according to the specifications of VDE0660, Part 506.

ΔT[K]: Difference in temperature between the ambience and inside the switch cabinet





Heat Abduction with Filterfans™

Follow the simple equation for calculating the required air flow volume:

$$V = \frac{3.1(Pd)}{\Delta T} \text{ [m}^3\text{/h]}$$

V[m3/h]: Flow volume for a filter fan

Pd[Watt]: Dissipation loss
Thermal power generated inside a switch cabinet by dissipation loss from components.

A[m2]: Difference in temperature between the ambience and inside the switch cabinet

In the course of development, absolute priority was given to the use of high-quality components (plastic material, fan, filter mat) and comprehensive transparent technical data. For this purpose we measured every Filterfan™ and exhaust filter in a test laboratory.

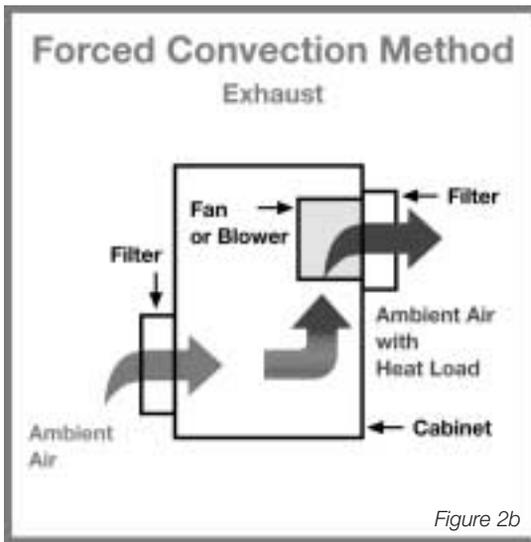
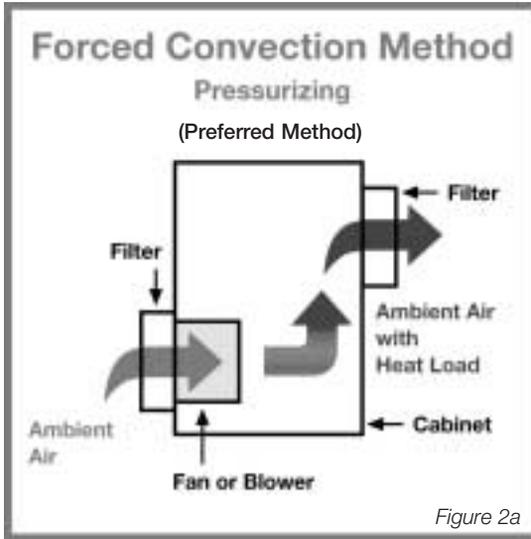
When considering the use of Filterfans™:

- Always use the Filterfan™ to propel the cool ambient air into the switch cabinet. This ensures that slight positive pressure builds up inside the switch cabinet in comparison to the ambience and that only air filtered by the Filterfan™ flows into the switch cabinet. The air propelled into the cabinet displaces the warm air which exits through the exhaust filter. If, however, the air is drawn out of the switch cabinet by suction power, unfiltered air can also enter through gaps and components
- If you install a combination of Filterfan™/exhaust filter, fit the Filterfan™ in the lower third of the switch cabinet if possible. The exhaust filter must be installed as near to the top as possible to prevent heat pockets in the upper part of the cabinet
- In switch cabinets consisting of several compartments, the cool air capacity required should be divided among two or more Filterfans™/exhaust fans. This measure helps to ensure a more acceptable distribution of temperature throughout the cabinet
- If you combine a Filterfan™ with two exhaust filters, the cool air divides into “Y” shape. In this way, with just one additional exhaust filter you can considerably improve the circulation inside the switch cabinet
- Install a thermostat that only trips the Filterfan™ when the temperature is too high. This can quite substantially increase the service life of your filter mat



(European Patent No. 0439667)

The Filterfan/exhaust filter is centered in the cutout and held in place across the 4 corners. Installation time is thus reduced from 12 minutes to virtually ZERO.



Steps for sizing an air conditioner — Proper selection of an air conditioner is determined by the following criteria:

- Required cooling capacity in BTUs/hr (steps 1-4)
- Mounting requirements (top or side mounting options)
- Dimensions of air conditioner and enclosure

Step One

1 Watt = 3.413 BTU/HR.
Determine the internal heat load in Watts that must be dissipated.

Step Two

1 m² = 11.76 ft²
Calculate the exposed surface area of the enclosure: $2[(h \times w) + (h \times d) + (w \times d)] \div 144 =$
Area (ft²).

Step Three

1°C or 1°KΔT = 1.8°F T
Determine the temperature differential by subtracting the maximum allowable temperature inside the enclosure (Ti) from the maximum ambient temperature outside the enclosure (To).
To - Ti = ΔT

Step Four

$[\text{Watts} \div \Delta T (\text{F}^\circ)] - [0.22 \times \text{Area (ft}^2)] = \text{Watts/F}^\circ$
Capacity Required BTU/HR. Capacity Rating

Heat Abduction with a Cooling Unit

Pfannenberg air/refrigerant cooling units operate on the principle of the Carnot cycle. This means that the cooling unit functions as a heat pump that “pumps” the thermal energy abducted from the switch cabinet (heat dissipated from the components) up to a higher level of temperature (the ambient temperature can reach levels as high as +131°F). The air inside the switch cabinet is cooled down by the evaporator and is at the same time dehumidified.

Cooling units are used if:

- The outside air cannot be used for cooling
- The required temperature inside the switch cabinet should be equal to or lower than the required ambient temperature
- The ambient air is extremely oily or rife with conductive dust

Selecting cooling units

- Ascertain the total dissipation loss from the components installed in the switch cabinet. Take into account the simultaneity factor, because rarely are all components in operation at the same time
- Also take the heat radiation from the switch cabinet into account. If $T_i < T_a$, this must also be added to the dissipation loss value
- Now select the necessary cooling unit in accordance with the required refrigeration capacity, ensuring that the cooling capacity of the cooling unit is at least equal to the dissipation loss value. Preferable is a figure 10% in excess of that value

Utilizing characteristic curves for proper selection of a cooling unit

Characteristic curves for all cooling units are available for contacting us. These diagrams allow you to determine the corresponding effective (useful) refrigeration capacity for any temperature. All relevant data for our cooling units result from tests in Pfannenbergs' own climatic chamber.

Example:

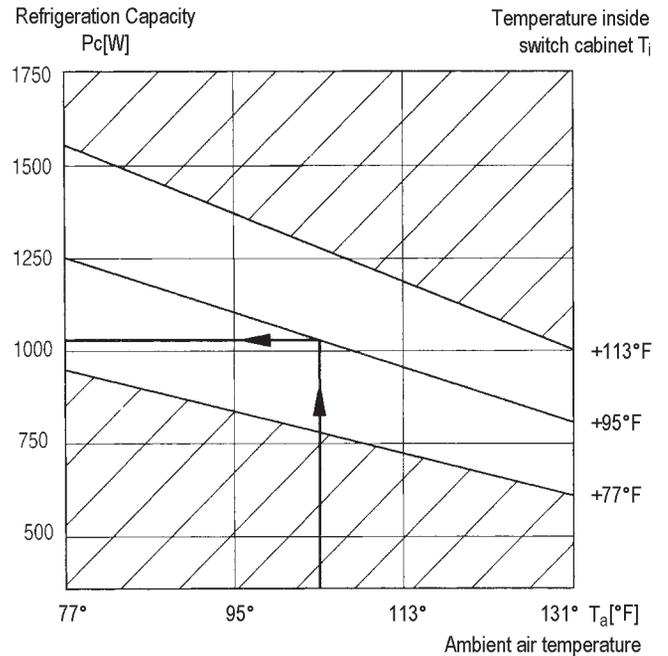
$T_a = 104^\circ\text{F}$ and $T_i = 95^\circ\text{F}$, where

T_i [°F]: Maximum admissible temperature inside the switch cabinet. This value reflects the maximum operating temperature of components installed in the switch cabinet. This usually ranges from approx. 95°F to 113°F .

T_a [°F]: Maximum ambient temperature. Temperature at which the switch cabinet is installed.

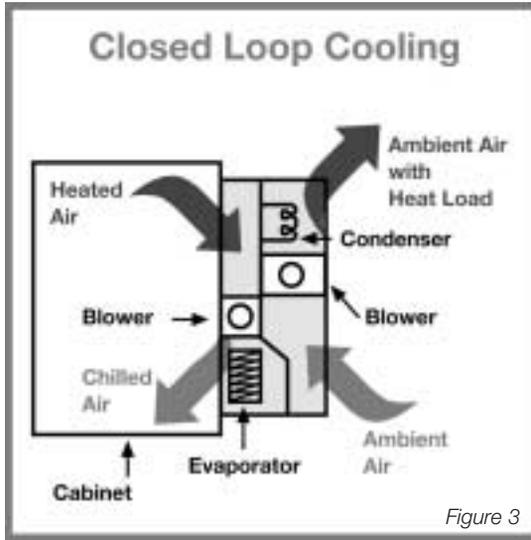
P_c [Watt]: Refrigeration capacity of a cooling unit. Only the effective or useful cooling capacity is shown.

Go to the known ambient temperature ($T_a = 104^\circ\text{F}$) and trace a vertical line up to the intersection with 95°F line. Then trace a horizontal line left of that intersection until it meets with the ordinate (vertical axis). This point shows the refrigeration capacity required. In this example, the following diagram shows that the value is 1040W.



Important information on the utilization of cooling units

- The refrigeration capacity should exceed the dissipation loss from the installed components by approximately ten percent (10%)
- The switch cabinet must be adequately sealed to prevent the inflow of ambient air
- Use the door contact switch to impede operation with open doors and consequent excessive accumulation of condensation
- Use cooling units with a generous clearance between air inflow and air outflow to prevent poor circulation
- Attach the condensate overflow hose included in the package of accessories supplied with the unit
- Make sure that the air inflow and air outflow in the external circuit of the cooling unit circulates satisfactorily to ensure that the thermal energy is released into the ambience
- When using top-mounted cooling units, make sure that components with their own fans do not expel the air directly into the cooling unit's cool air outflow. This counteraction between the two airflows would otherwise substantially reduce the refrigeration capacity and could cause heat pockets.
- Make sure that the switch cabinet stands up straight. Otherwise the condensation cannot drain properly from the top-mounted unit
- Setting the temperature to the lowest setting is not the optimal solution due to condensation issues. The value we have preset on the cooling unit is a sound compromise between cooling the inside of the switch cabinet and the accumulation of condensation



Cooling Control Cabinets

Most electrical & electronic control systems generate substantial amounts of heat during operation. This heat factor intensifies as controls are made more compact, perform more functions, or are placed in more confined areas. Additional problems are encountered when the electronic process control system is located on-site in an industrial setting, as opposed to a clean computer room. For instance, ambient temperatures found in a steel mill can be locally very high. The factory environment can be hostile to the point that performance and effective life of electronic components are materially reduced, or the control system fails completely. Moisture-laden air and airborne particulate matter might be present to adversely affect electronic components, as is true in the paper manufacturing industry or in grain storage facilities. Our air conditioners are designed to perform reliably under many of these harsh conditions and to provide the cooling and environmental protection required by sensitive electronic production control systems.

Factors affecting model selection

Use this section as a basic outline or checklist of the various conditions to be considered when choosing a cooling unit for a certain application.

The following three factors must be considered when selecting a cooling unit:

1. Internal Heat Load

This is the heat dissipated by electronic controls. It is expressed in watts. One watt equals 3.413 BTU/hr. Thus, to obtain the approximate cooling capacity required to remove a specific heat load, the following formula can be used:

$$\text{Watts} \times 3.413 = \text{BTU/hr}$$

For example, a heat load of 800 watts requires an air conditioner capable of removing at least 2,730 BTU/hr

2. Resistance to air flow in the enclosure

Air-flow is measured in cubic feet per minute (CFM). Creating appropriate air flow requires that air pressure be produced by a blower within the air conditioning enclosure. Resistance to blower-produced air flow is created by obstructions within the cabinet's air-flow path. This resistance is called static pressure (SP) and is measured in inches of water column.

The effect of significant resistance in the cabinet's air flow due to static pressure is that it produces a drop in air pressure, or differential, from the air velocity produced by the blower. This reduction in cool air flow will decrease the effective capacity of the cooling unit. So when selecting the proper cooling unit, allowances must be made for static pressure.

3. Heat Load From the Surroundings

Ambient conditions can cause a heat gain in the enclosure. The rated capacity of the cooling unit must be sufficient to handle this heat gain. When evaluating the additional heat load gained from the surroundings, consider the following:

Insulated Cabinet — Normally, well-insulated cabinets will not gain sufficient ambient heat to affect an air conditioner's operation. BTU/hr ratings for our air conditioners have been established at the maximum ambient operating temperature of 125°F. A substantial improvement in heat removal occurs when operating in ambient temperatures below 125°F.

Uninsulated Cabinets (most common) — Obviously, this design places more of a burden on the cooling unit. Heat is conducted to the cool side. Thus, high ambient heat will be readily transmitted into the cooler enclosure. To determine the additional capacity required of our air conditioner installed in an uninsulated cabinet, the surface square footage of the enclosure must be calculated to obtain the total effective heat transfer area. For this calculation, use the surface area of the sides, plus the area of the top, and omit the bottom area of the cabinet.

Air movement outside the uninsulated cabinet will increase the heat conducted from the ambient into the enclosure. When there is little or no air circulation outside the cabinet, the layer of air immediately adjacent to the exterior cabinet walls act as an insulating film. Exterior air movement dissipates this insulating layer of air in proportion to the velocity of the air flow. Substantial ambient air circulation will increase the transmitted heat load imposed on the cooling unit. If the cabinet being cooled is not airtight, then high ambient relative humidity will adversely affect the cooling effectiveness of the air conditioner. When humid air infiltrates a poorly sealed enclosure, the air conditioner is required to use up valuable BTU/hr capacity just to condense the moisture from the internal air. Conversely, if the cabinet is well sealed, high ambient relative humidity has very little effect on the heat capacity of the air conditioner.



Why Use a Heater?

Hubbell Wiegmann heater products protect electronic and electrical components from temperature problems that are below acceptable tolerances. There are obvious circumstances when extremely low ambient (outside the enclosure) temperatures would require a heater, but there are also less apparent times that a heater should be considered. For example, a system may run all day having its components generate heat, but once the system shuts down for the night, the quick drop in temperature could cause condensation and possible corrosion — a heater could be used to maintain a safe and constant temperature.

Heater Sizing

Formula for sizing Hubbell Wiegmann enclosure heating products:

$$P_H = (\Delta T \times k \times A) - P_v$$

Variables:

P_H = Total power required in Watts for application.

ΔT = Difference between the minimum required enclosure interior temperature and the lowest possible exterior temperature, in degrees Kelvin.

“DT” can be calculated using the following formula:

$$\frac{(IT) - (ET)}{1.8} = \Delta T \text{ in } ^\circ\text{Kelvin}$$

(IT) – Minimum required enclosure interior temperature [°F]

(ET) – Lowest possible exterior temperature [°F]

k = Heat transmission coefficient convection of enclosure material in quiet air.

Painted Steel	0.511 W/(ft ² °K)
Stainless Steel	0.344 W/(ft ² °K)
Aluminum	1.115 W/(ft ² °K)
Plastic (or insulated stainless)	0.325 W/(ft ² °K)

A = Enclosure surface area in ft.² “A” can be calculated by using the following formula (assuming a wall-mounted enclosure):

$$1((H/12) \times (W/12)) + 2((W/12) \times (D/12)) + 2((H/12) \times (D/12)) = A \text{ in ft.}^2$$

H = Height of enclosure (in inches)

W = Width of enclosure (in inches)

D = Depth of enclosure (in inches)

P_v = Existing power from installed components (Watts).

Sample with solution:

Required sizing information:

- Wiegmann Painted Steel Enclosure = N12161206 (H = 16", W = 12", D = 6")
- Minimum required enclosure interior temperature in Fahrenheit=50°F (IT)
- Lowest possible exterior temperature in Fahrenheit = -30°F (ET)
- Existing components generating 50 Watts (P_v)

$$\Delta T = \frac{(50) - (-30)}{1.8} = 44.44$$

$$k = 0.51$$

$$A = 2((16/12) \times (12/12)) + 2((12/12) \times (6/12)) + 2((16/12) \times (6/12)) = 4.99$$

$$P_H = (44.44 \times 0.51 \times 4.99) - 50 = \mathbf{63 \text{ Watts}}$$
 needed to heat the enclosure

