Special-Purpose Air Conditioners Cool Electrical Enclosures

Understanding how these "special" units work can help you decide if they are right for your equipment cooling needs.

By Bruce K. Kreeley, Kooltronic, Inc.

Heat-producing power and control components are being packaged in less space, increasing the power densities in electronic and industrial equipment enclosures. Computers, programmable logic controllers, microprocessors, variable-speed drives, power conversion and storage devices have found their way into every industrial and commercial environment.

The problem of dissipating the heat generated to prevent premature failure or process shutdown can be solved by several means. The surface area of the enclosure itself may serve as a passive means to dissipate this heat, provided the ambient conditions are below the desired enclosure interior temperature and the internal heat load does not cause an unacceptable rise in temperature. When this is not possible, an active approach is necessary. Open-loop powered ventilation or closed-loop cooling may be used.

Open-loop ventilation uses ambient air to remove the heat and may consist of small muffin-type fans that exhaust or supply an electrical enclosure, at times with filters to prevent airborne aerosols and dust from entering the enclosure. The fans have the advantage of utilizing

Typical Special-Purpose Air Conditioner

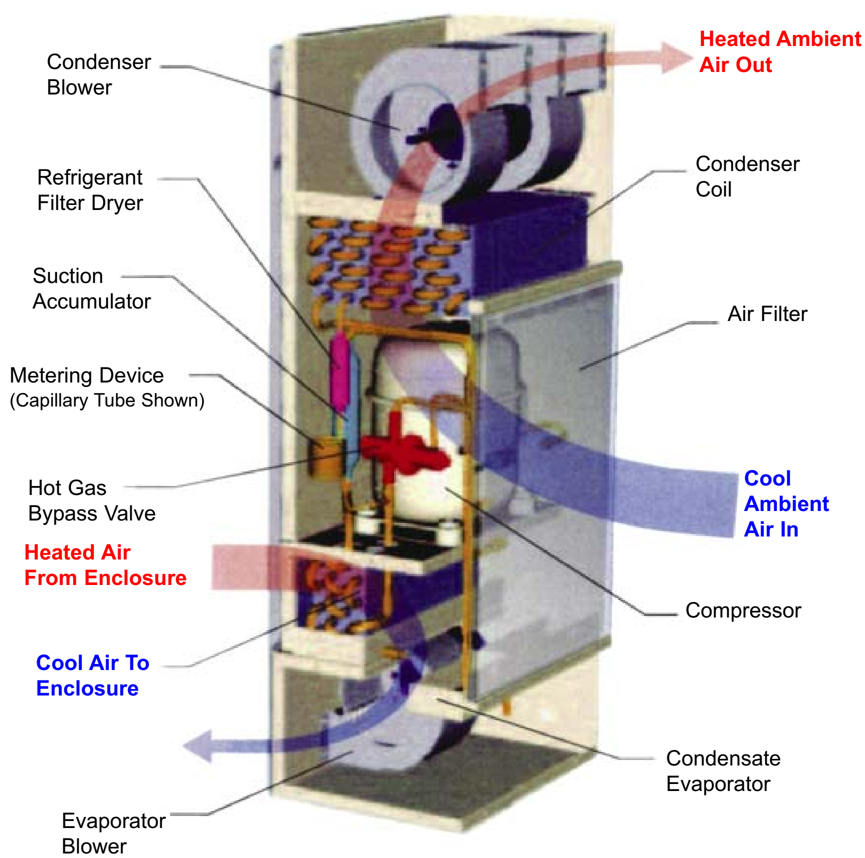


Figure 1. A typical special-purpose air conditioner is best suited for enclosure cooling applications subject to dust, dripping liquids, rain, wash-down and corrosive atmospheres.

a minimum of enclosure space and will move a substantial volume of air where flow is unimpeded. Cost and complexity is minimized.

Where density of components impedes airflow, packaged blowers or motorized impellers may be arranged to operate against these higher static pressures. With a rack enclosure, supplemental fan trays may be used to spot cool or supplement other air-moving devices.

If maximum internal enclosure design temperatures cannot be maintained using open-loop ambient air cooling, closed-loop devices must be considered. Air-to-air, water-to-air or thermoelectric heat exchangers and air-conditioning units are able to cool a confined amount of air within an enclosure. Heat is transferred to the respective device's ambient side, where an air mover or water coil transfers the heat to the room or outdoors.

Air conditioners and water-to-air heat exchangers provide the greatest capacity to transfer heat in closed-loop conditions. They have the unique ability to maintain a lower-than-ambient temperature and reduce the humidity within the controlled space. It is important to note that enclosure design temperatures may exceed ambient temperatures yet be below the electronic components' design limits. Depending on the NEMA enclosure type, which designates the environmental hazard from which the contents are being protected, an air conditioner can be provided to operate in most locations. Locations subject to dust, dripping liquids, rain, wash down and corrosive atmospheres can utilize special-purpose air conditioners.

A Closer Look

In a typical special-purpose air conditioner, heat is transferred from the enclosure components by circulating air around and through them. The air then is cooled, dehumidified and returned to the enclosure without the admission of air from the outdoors. The heat is removed from this air within the air conditioner and discharged by means of a vapor compression refrigeration cycle. This takes place in a hermetically sealed system, utilizing either an air- or water-cooled condenser coil (figure 1).

The compressor forces refrigerant, in vapor form, into the condenser coil, where it is cooled by ambient air. As it cools, the refrigerant condenses into a liquid that is passed through a filter to remove impurities and excess moisture. The liquid refrigerant flow is metered by a thermostatic expansion valve or capillary tube to control its admission to the evaporator coil, which is a part of the closed loop inside the enclosure.

The refrigerant enters the evaporator as a liquid beginning to vaporize. As the blower or fan-driven heated air from the enclosure passes through the evaporator coil, the heat is transferred to the refrigerant, converting the refrigerant to vapor. High levels of humidity present in the air are removed by condensation; the water is drained to the outside and evaporated in some cases. The cool, dehumidified air is returned to the enclosure. After the heat is transferred to the refrigerant in the evaporator, the refrigerant passes into an accumulator, where any remaining liquid is separated. The gas then returns to the compressor to repeat the cycle in a continuous process.

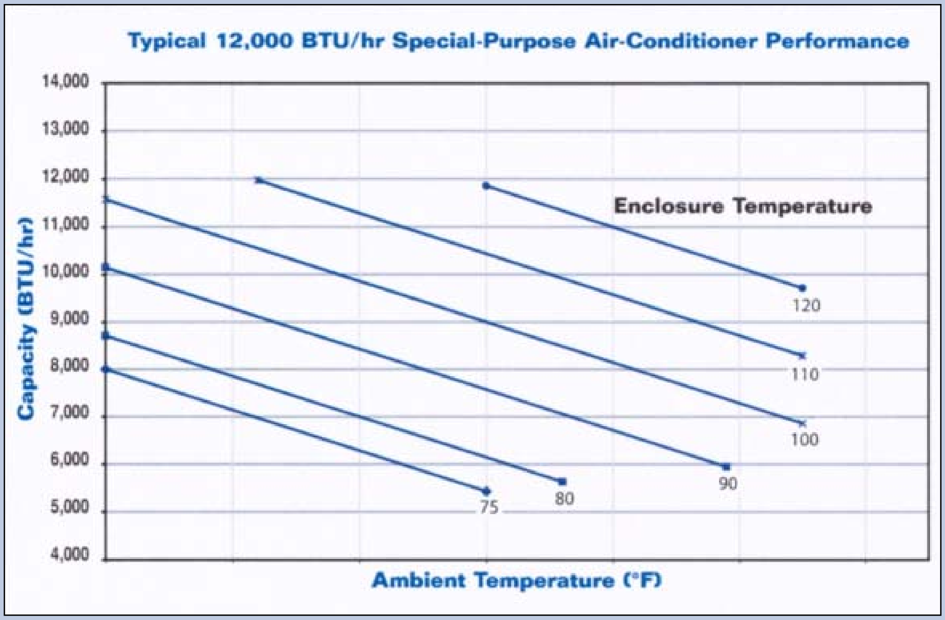
Control of the system generally is kept simple. When power is applied to the air conditioner, the evaporator blower starts and runs continuously. If the temperature within the enclosure is high, the condenser blower and compressor turn on, operating until the thermostat setting is reached. The thermostat is used as a low-limit setting -- typically 75°F (24°C) -- serving as the point at which the compressor and condenser fans or blowers are turned off. Air within the enclosure continues to be circulated by the evaporator blower or fan, picking up heat from the components within the enclosure.

The thermostat has a differential setting that is typically 12 to 15°F (7 to 8°C) above the low-limit setting. When the air circulated within the enclosure rises by this amount, or at about 90°F (32°C), the compressor and condenser blower turn back on, reducing the enclosure internal air temperature once again. Therefore, at startup of an enclosure system, it would be normal

Figure 2. Enclosure cooling air conditioners typically carry agency markings such as UL, which designates the environmental hazard from which the contents are being protected. This marking should be matched to the enclosure to be cooled. Typical examples include NEMA 12 (left), NEMA 3R middle and NEMA 4X (right).

Tips for Selecting Special-Purpose Air Conditioners

Follow these tips to ensure reliable operation.



- ✔ Be sure not to oversize the unit.
- ✔ Be certain that both the evaporator and condenser airflow paths cannot short circuit or airflow are impeded.
- ✔ Be cautious of adding protective covers to the outside of the unit, which may reduce airflow and unit thermal performance.
- ✔ Seal the electrical enclosure to prevent humidity and outside air from entering.

Closed-loop enclosure cooling is the goal. Consult performance data or contact the manufacturer for temperature conditions other than the rating points shown in most catalogs.

for the internal temperature to rise to this temperature before the refrigerated cooling would begin. As the air cools, a temperature balance within the enclosure is reached. Ideally, the compressor and condenser fan run most of the time until the heat load changes.

Enclosure cooling is not comfort cooling as found in homes and buildings. Heat-producing power and control components typically are limited to maximum enclosure air temperatures of 100 to 110°F (38 to 43°C). The actual component surface temperatures are higher. Maintaining enclosure temperatures too low often becomes problematic. Condensation may form on live electrical surfaces if their temperature falls below the dew point of the air. Subsequent corrosion or electrical safety become serious issues.

Various control features are available to operate in cooler ambient conditions found outdoors or in poorly heated settings. Compressor short cycling controls may be added to prevent damage caused by frequent starting when heat loads fluctuate.

Enclosure cooling air conditioners typically carry agency markings such as UL, which designates the environmental hazard from which the contents are being protected. This marking should be matched to the enclosure to be cooled. Typical examples include NEMA 12 for indoor use, protection from dust and dripping liquids; NEMA 3R for outdoor use and rain-proof applications; and NEMA 4X for outdoor or indoor use to provide protection from wash-down and corrosive environments (figure 2).

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Sizing calculations for an air conditioner can be accomplished using software available on manufacturers' web sites or supplied on disk. The internal heat load is determined based on measurement or estimation. Enclosure surface area, desired maximum internal enclosure temperature, degree of thermal insulation, if any, ambient temperature and, for outdoor use, solar load are used to determine the total heat load in BTUs per hour. It is important to note that the solar load and the degree of insulation can become significant.

A properly sized, well-designed system, free of refrigerant leaks and with a stable power supply will cool critical systems -- trouble-free -- for many years.

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For more information ...

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Kooltronic Air Conditioner Selection Guide

Series	Indoor	Outdoor	NEMA 12	NEMA 3R	NEMA 4	NEMA 4X	480 Volt	Panel Mounted	Rack Mounted	Top Mounted	BTU/H Capacity	UL Recognized	UL Listed
Guardian	✔	✔			✔			✔			1,000 - 26,000	✔	✔
GuardianX	✔	✔				✔		✔			1,000 - 26,000	✔	✔
Guardian 480 Volt	✔	✔			✔		✔	✔			3,000 - 26,000	✔	✔
GuardianX 480 Volt	✔	✔				✔	✔	✔			3,000 - 26,000	✔	✔
Hazardous Location	✔	✔	✔	✔	✔	✔	✔	✔			6,000 - 24,000	✔	✔
SlimKool	✔	✔	✔	✔	✔	✔	✔	✔			4,000 - 11,000	✔	✔
Micro-Mini (Traditional Series)	✔		✔					✔			1,000	✔	✔
Trimline	✔		✔					✔			2,000 - 16,000	✔	✔
Intrepid	✔	✔		✔				✔			30,000	✔	
Horizontal Internal (RML)	✔								✔		5,000	✔	✔
Horizontal Internal (H9 & H10)	✔								✔		3,500	✔	
Horizontal External	✔									✔	2,500 - 12,000	✔	
Advantage Horizontal External	✔	✔		✔						✔	3,000 - 12,000	✔	✔
Water Cooled	✔							✔			4,000 - 12,000		

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