Electrical Enclosure Cooling With Special Purpose Air Conditioners

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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, providing 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 a minimum of enclosure space and will move a substantial volume of air where flow is virtually 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.

Where maximum internal enclosure design temperatures cannot be maintained using open loop ambient air cooling, closed loop devices need to be considered. Air to air heat exchangers, water to air heat exchangers, 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 devices' ambient side where an air mover or water coil transfers the heat to the room or outdoors.

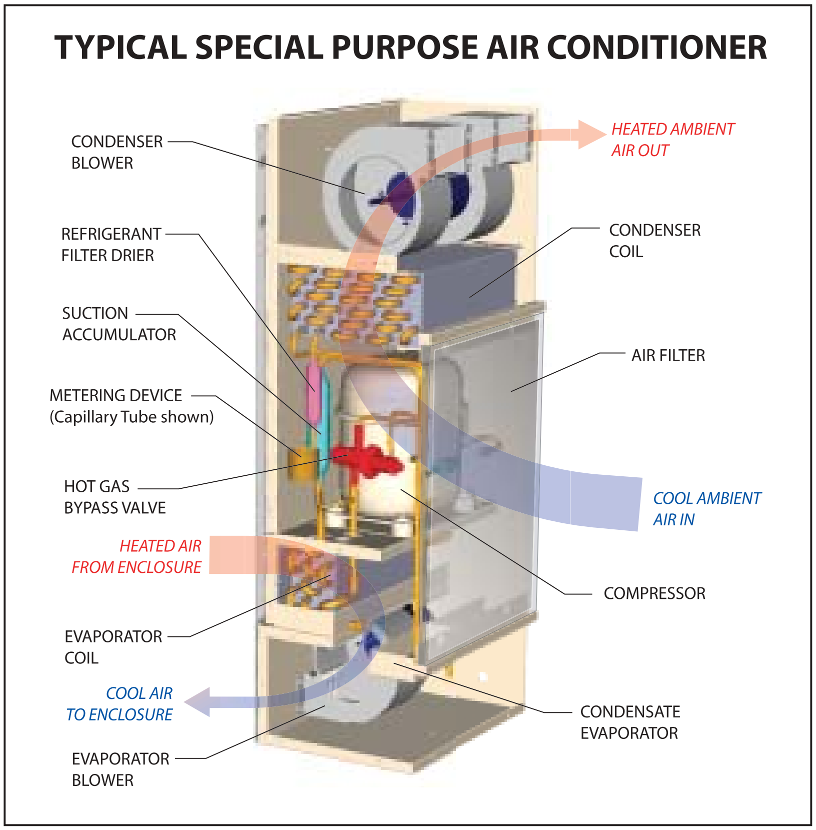

Figure 1

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 the ambient temperatures, yet be below the electronic components' design limits. Depending upon 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 these "Special Purpose Air Conditioners".

A typical "Special Purpose Air Conditioner" operates as follows. Heat is transferred from the enclosure components by circulating air around and through them, the air is then 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-cooled or water- cooled condenser coil. A schematic of a typical Air Conditioner is illustrated (see 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, which 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 on the inside of 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. This cool, dehumidified air is then 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 is generally 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 the compressor turn on, operating until the thermostat setting is reached. The thermostat is used as a low limit setting. This is typically 75°F, the point at which the compressor and the condenser fan 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 12-15 degrees above the low limit setting. When the air circulated within the enclosure rises by this amount, or at about 90°F, the compressor and condenser blower turn back on reducing the enclosure internal air temperature once again. Therefore, at start up of an enclosure system, it would be normal for the internal temperature to rise to this temperature before the refrigerated cooling would begin. As the air cools, a balance of temperature within the enclosure is reached, ideally the compressor and condenser fan continue to run most of the time until the heat load changes.

Figure 2

Figure 3

It is important to understand that enclosure cooling is not "comfort "cooling as found in homes and buildings. Heat producing power and control components are typically limited to maximum enclosure air temperatures of 100°F to 110°F. 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 becomes a serious issue.

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.

The air conditioner typically carries an agency marking such as UL, Underwriters Laboratories 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, (indoor use, protection from dust and dripping liquids) (see Figure 2), NEMA 3R, (outdoor use and rain proof) (see figure 3) and NEMA 4/X (outdoor or indoor use, protection from wash-down and corrosive environments) (see figure 4).

Figure 4

Sizing calculations for the selection of an air conditioner are accomplished with ease via software available on manufacturers' websites or on available software copies. The internal heat load is determined based upon 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 BTUH. It is important to note that the solar load and the degree of insulation can become very significant. Entering a closed automobile after it has sat in the hot summer sun illustrates this point.

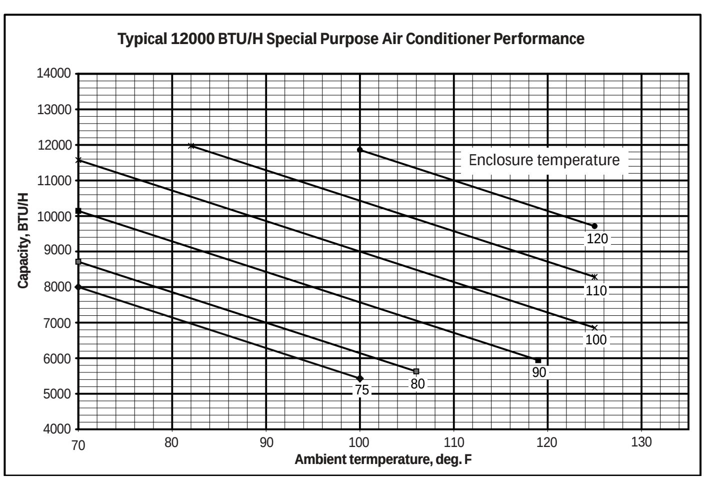

Figure 5

For best results be careful not to oversize the unit. Be certain that both the evaporator and condenser air flow paths cannot short circuit, or are impeded. Be cautious of adding protective covers to the outside of the unit which may reduce air flow 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. Typical performance is shown in figure 5. A properly sized, well designed system, free of refrigerant leaks, with a stable power supply will cool critical systems trouble free for many years.

Should you have any technical questions please contact us at techquestions@kooltronic.com.