Cooling Process Control Panels Effectively

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Over the past few decades, the use of sophisticated high density electronics within automation and process control panels has become commonplace. Thermal management and its related costs for these electronic enclosures are very important considerations in managing these valuable assets. Choosing the appropriate and most cost and energy efficient cooling solution from the many types available requires knowledge of their individual strengths and weaknesses, and the ability to match that to the operational environment.

Knowledge of the panel equipment manufacturer's specifications regarding the maximum allowable operating temperature is the starting point in this decision process. Most modern electronics, including common devices such as VFD's, PLC's, transformers and relays are designed for internal panel air temperatures between at least 104°F (40°C) up to 122°F (50°C). Common sense dictates maintaining the panel temperature at or below the lowest required operating temperature.

Leaving the panel open on unusually hot days provides ambient air temperature cooling and can resurrect an overheated device, but besides the OSHA safety issues, this approach insures that dirt, oil, corrosive moisture and other hazards will attack the electronics.

Halfway measures such as cutting holes in the panel and installing filtered fans can work in clean environments, but few industrial settings are so contaminant free that this is a practical approach, and it cannot be used for outdoor installations. If the filter is dense enough to prevent the entry of contaminating dirt and moisture, it will quickly clog up and be a preventive maintenance (PM) headache.

In the above approaches, costly damage to the panel's electronics and the resulting downtime is a matter of when, not whether, it will happen.

It's a classic Catch 22; dirt and moisture, or heat damage – you must do battle with one or the other. Without some form of cooling, problems or even complete failures will occur due to heat buildup within these enclosures if the heat load is beyond the ability of the cabinet's natural convection cooling to dissipate**.**

The following are the most popular enclosure cooling choices in the marketplace, along with some general cost considerations and assumptions needed to make a good decision:

- Thermoelectric devices. These solid-state air conditioners provide effective cooling but require one watt of power to remove one watt of heat. They are typically used only in very small cabinets and are not very cost effective.

- Compressed air coolers. They use plant air to create a 'cyclone' effect that cools the inside of the cabinet. The high cost of a compressed air supply should be considered, as should whether that air is dry and oil-free. Like the fan and filter method, short term gains are often offset by long term maintenance issues and hidden costs. Hank Van Ormer of Air Power USA Inc, a noted expert on the subject of compressed air technology, wrote, “Just how expensive is compressed air? It takes about 8 HP of electrical energy to produce 1 HP worth of work with compressed air. Do you think your electric power is expensive? Your air power is 8 times more!” And that was in 2006!

- Air conditioners. These are a frequently used panel cooling method. When electronics first made their way into the plant, air conditioners had to be used because the low thermal thresholds of early electronics required that the devices inside be “refrigerated” to below ambient conditions. But in today’s world, components are made to withstand much more heat without harm or performance de-rating; they do not require “refrigeration.” Since air conditioning units cost more to install and maintain and use far more energy than most other options, where possible they are being replaced by alternative cooling solutions.

- Heat exchangers. Two of the most cost effective, reliable and energy efficient alternative cooling methods are the air-to-air and air-to-water heat exchanger. Where appropriate, the heat exchanger delivers the best value and ROI due to its low initial cost, negligible power consumption and long life. These designs have become increasingly popular both in new panel installations and retrofit of older panels.

The pros and cons of heat exchangers

Air-to-water heat exchangers are a popular choice. The water industry has a unique advantage with its ability to employ easily available sources of water (typically under 2 GPM) for use in air-to-water panel coolers. These devices cost pennies on the dollar per BTU/hr compared to all other methods, and are the most “green” and environmentally friendly solution as well. Air-to-water heat exchangers are closed designs, completely reliant on water temperature for their cooling effectiveness, and with no exposed fans or fins to require filtering in dirty environments. They’re also a natural fit for hazardous location installations; with a purged panel, standard muffin fans versus the highly costly explosion proof versions can be used.

Lastly, air-to-water units can address even large heat loads using “ground temperature” water in the 65°F (18°C) range. Also, the clean but heated outlet water can often be reused in some other process, taking advantage of the heat energy it carries with it.

However, few facilities have easy access to a water supply for this type of cooling.

The heat pipe-based, air-to-air heat exchanger is the next and final suggestion. Taking advantage as it does of simple physics to offer very high thermal transfer capabilities while consuming very low electrical energy, it's become one of the most widely accepted cooling technologies. These units will perform at their full rated level for upwards of 15 years, with the only failure point and replacement cost being the simple and inexpensive electric muffin fans they employ.

According to Van Ormer, "Open blow, refrigeration and compressed air cooling may be replaced with 'heat pipe' heat exchangers with a potential energy savings of 3.5 to 4kW each on an average cabinet. The initial cost in the low $1,000 range offers a resultant power savings of $1,000-2,000/year each."
The Achilles heel of this approach is its reliance upon ambient air temperature. In high ambient conditions where there is insufficient panel to ambient delta T for effective cooling, than one of the above below-ambient solutions is a necessity.

Whatever your requirements, look at the long-term energy and maintenance costs as well as initial purchase price when evaluating your panel cooling alternatives. The initial cost is known, but you should probably assume that operating and energy costs will only continue to climb. Give them serious consideration when making your decision.

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Deciphering Panel Temperature Increases (SIDEBAR)

Without some form of cooling, problems or even complete failures will occur due to heat buildup within these enclosures if the heat load is beyond the ability of the cabinet's natural convection cooling to dissipate**.** This chart shows various panel temperature rises above ambient temperature due to watts of wasted heat load, and the various BTU/hr cooling results.

Un-insulated NEMA 12 and above metal panels dissipate heat via natural convection, which occurs primarily along its vertical walls, not from the top as intuition might lead us to expect. So, one simple cooling solution for low heat loads is to place equipment in oversized panels that maximize vertical height over width and depth as much as possible.

As the chart indicates, in ideal conditions (a freestanding panel with airflow all around it, no sources of heat such as transformers sitting on top of it, etc) a 72 in by 36 in by 24 in panel can convect almost 500 watts of waste heat with only a 15°C/27°F rise in panel temperature above ambient.

That's great if your ambient is climate controlled and never rises above 75°F (24°C), but very few environments are that ideal. And most heat loads are far larger than 500 watts. And of course, the cost of such an oversized panel, especially if it must be stainless steel, can exceed the cost of other cooling alternatives.

If the required panel internal temperature is below the peak ambient the panel will experience at it’s location, then a below-ambient cooling solution such as air-to-water heat exchangers, compressed air or air conditioning is a must. With a sufficient delta T between the panel requirement and the outside, ambient air temperature will exist. A heat pipe-based heat exchanger is often the ideal and most cost effective methodology.