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Advantages of Indirect Cooling Methods for Variable Frequency Drive (VFD) Applications

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ADVANTAGES OF INDIRECT COOLING METHODS FOR VARIABLE FREQUENCY DRIVE APPLICATIONS

Introduction

Variable Frequency Drives (VFDs) historically were designed to be installed for indoor applications where the electronics are not exposed to the weather and elements. The vast majority of VFD installations are typically in machine rooms or other indoor weather-protecting environments. However, over the years as new equipment and technology has been developed, the need for VFDs that can withstand outdoor environments and weather has followed suit.

Typically, integrators or panel shops will use an indoor rated VFD NEMA Type 1 and install it in a NEMA Type 3R outdoor rated enclosure and add cooling system to keep the VFD operating properly in extreme temperatures.

There are a number of cooling methods that manufacturers typically use, however, there are significant and measurable advantages using an indirect hybrid cooling design.

Summary

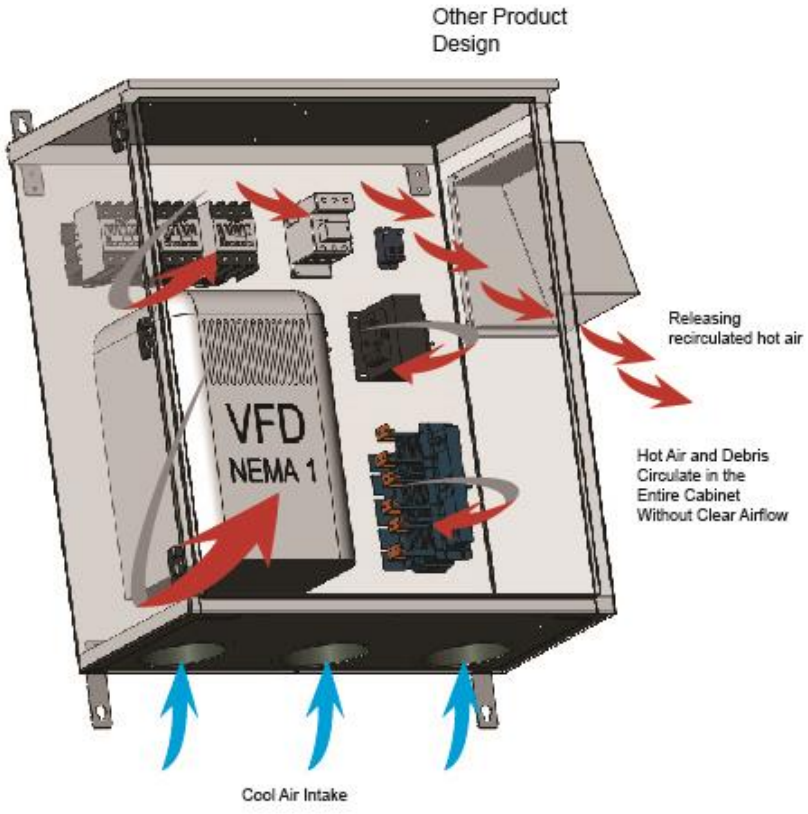
This paper will review four common cooling options used by other manufacturers and integrators. We will explain how they work and outline the advantages and disadvantages of each method, and why Phase Technologies uses a unique indirect hybrid cooling design in our NEMA 3R outdoor rated enclosures.

Common Cooling Methods for VFDs

Direct Cooling

Direct cooling is typically an inexpensive method to cool a VFD installed in an outdoor rated enclosure. The installation simply uses a multitude of fans, a control transformer, and often a thermostat to control the fans.

With these few additional components, the system forces outside air into the enclosure. The VFD then draws the unfiltered air through its heat sinks, and across its internal components.



While this is an inexpensive and simple way to cool the VFD system, the downside is air flows directly across the internal electronics and subjecting them to dust, humidity, and debris from the outside air.

By allowing this contamination to directly contact sensitive electrical components of the VFD, the life of the product may be substantially degraded. This can lead to unexpected outages and potentially expensive critical component failures.

The obvious solution for dealing with the contaminated air in a direct cooling method is to install filters on the inlet of the enclosure. While this sounds simple enough, filters have several drawbacks.

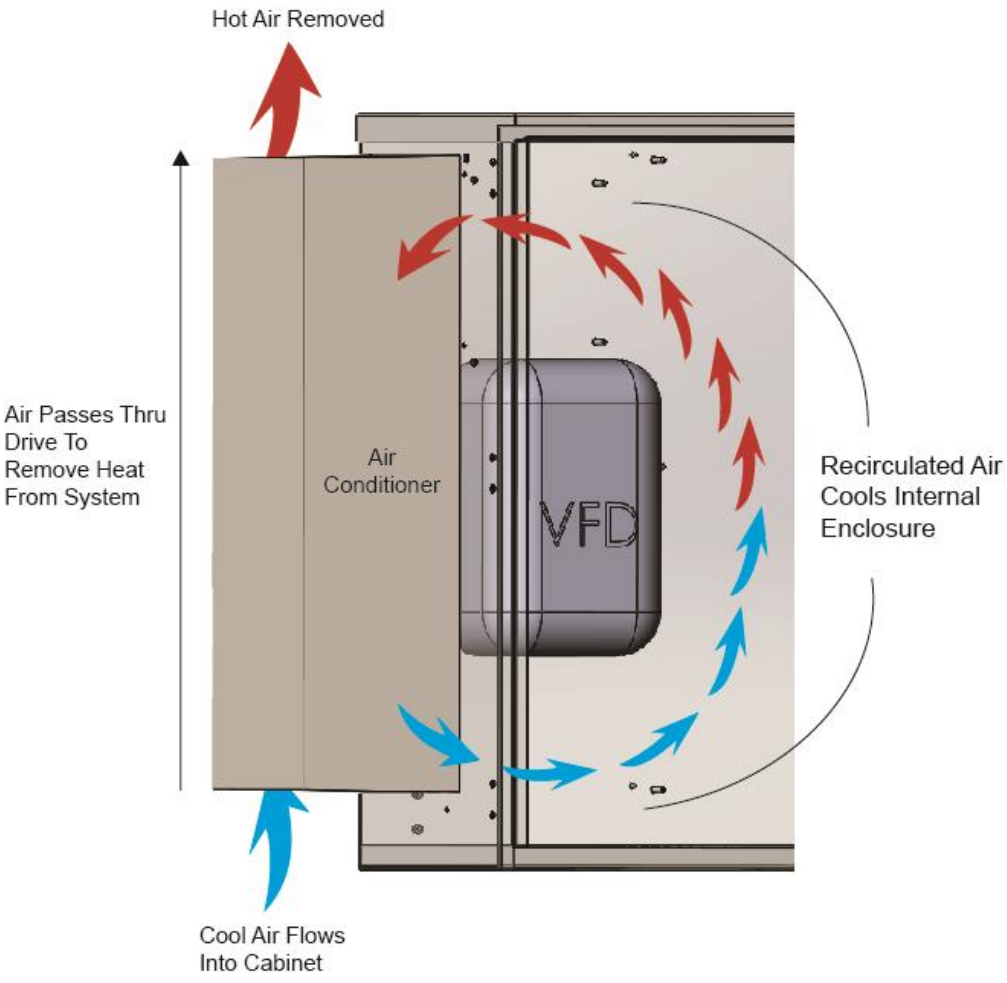
Most importantly, filters restrict air flow which limits the system's ability to cool effectively. To compensate for the filters, larger or additional fans are required. This increases cost, operation efficiency, and overall performance. Furthermore, filters require frequent and long-term maintenance to keep the VFD running continuously.

Indirect Cooling

Air Conditioning

Air conditioning (AC) is a method of cooling where the internal air temperature of the enclosure is lowered using a compressor, fan, refrigerant, and heat exchanging coils. The hot and cold air is exchanged through an intake and exhaust in the enclosure.

AC systems offer the advantage of cooling by indirect means, where the air circulating within the VFD is not exposed to the contaminants of the outside air. It extends the life of the VFD, leads to fewer outages, and can operate in higher ambient temperatures compared to VFDs using other standard cooling methods.



The disadvantages are:

- It is expensive to install
- Complex to integrate
- Inefficient to operate

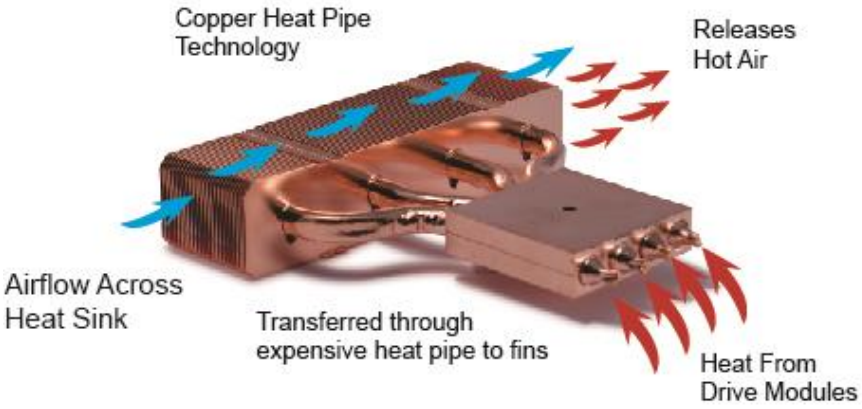
Another disadvantage of the AC system is while it cools the VFD by an indirect means, it exchanges the heat by direct means, which subjects its own internal components to debris and contaminants.

This reduces the life of the AC system, results in frequent maintenance and can be the cause of premature failure. Furthermore, when any part of an AC system fails, the entire VFD must be shut down and the AC system must be serviced or replaced.

Copper Heat Pipe Technology

Another method, more advanced and efficient compared to direct cooling and air conditioning is a copper heat pipe.

This offers an improved cooling solution over traditional heat sink designs. These heat pipe assemblies use a compressed gas medium located directly under the VFD's power switching components.



Copper heat pipes transfer localized heat away from sensitive components to heat exchanging fins directly in contact with outside air. Heat is transferred to the circulating air which keeps the VFD operating at a safe temperature.

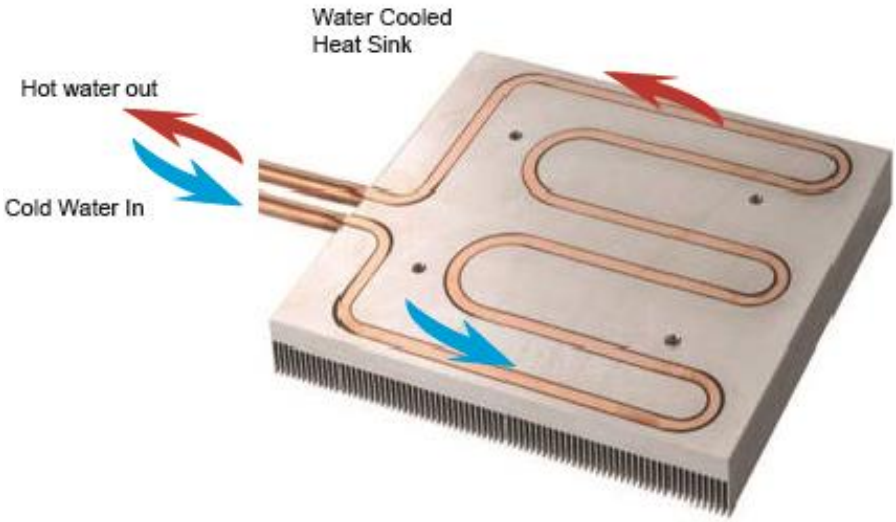
While this is an effective means of cooling a VFD, it comes at the expense of nearly ten times the cost of standard cooling technology. The extra expense of this copper design and installation makes it prohibitive for many manufacturers to keep their costs at a reasonable level for the end user.

Water Cooling

Water cooling is similar to copper heat pipe technology but offers a more effective means of heat transfer. Water cooling uses a liquid medium flowing directly under the VFD's power switching components.

Closed loop systems involved complex pumping systems. Also, in-order to maximize efficiency of a water cooled system, a large, bulky, radiator is required.

Many VFD applications involve



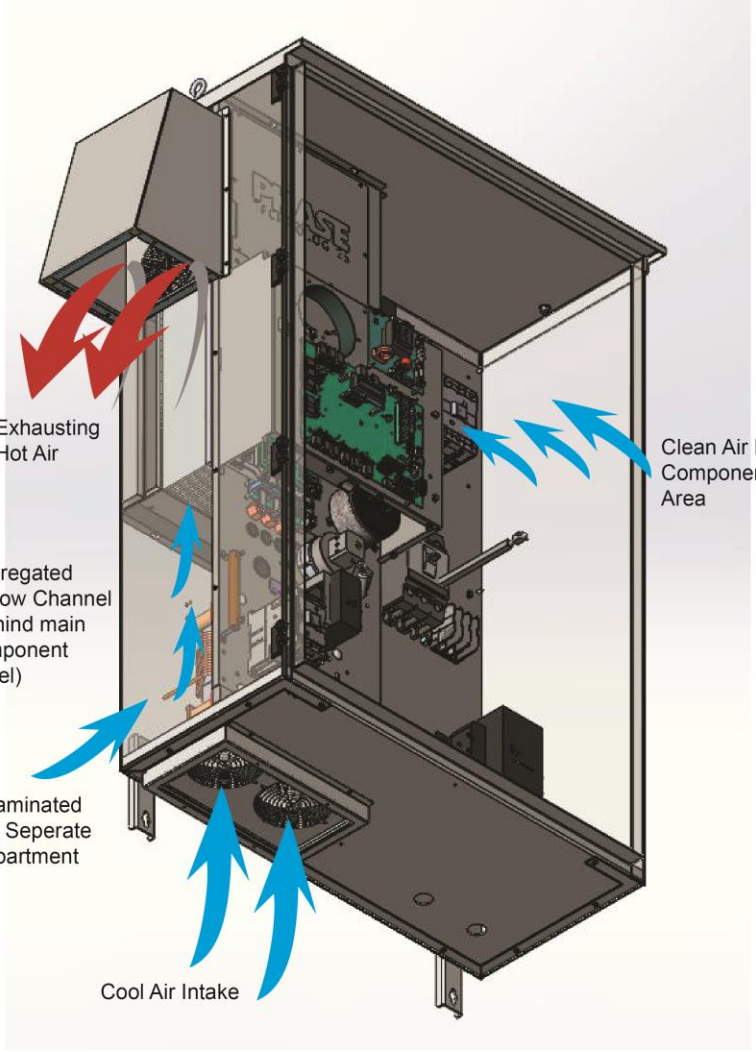
pumping cold water, which makes integrating a water cooling system seem more convenient. However, it creates a few key issues. The first of which is the water is not clean, debris and minerals will lead to reduced flow over time and eventually cause a system failure, which is costly and difficult to repair.

Secondly, if the VFD is installed in an area which experiences freezing temperatures, it must be carefully winterized to avoid problems and costly repairs. Similar to heat pipe technology, water cooling methods are highly effective, but cost prohibitive for typical VFD applications.

Phase Technologies' Approach to Cooling

Phase Technologies has engineered an indirect hybrid cooling design which allows us to cool the VFD in a cost effective manner (similar to a direct method) without the risk of exposing the sensitive electronics to external contaminants.

This is accomplished by directly integrating the VFD and its internal cooling technology into a NEMA 3R outdoor enclosure with a separate compartment for the cooling system. Similar to direct cooling, unfiltered outside air is forced through the enclosure as a cost-effective cooling method.

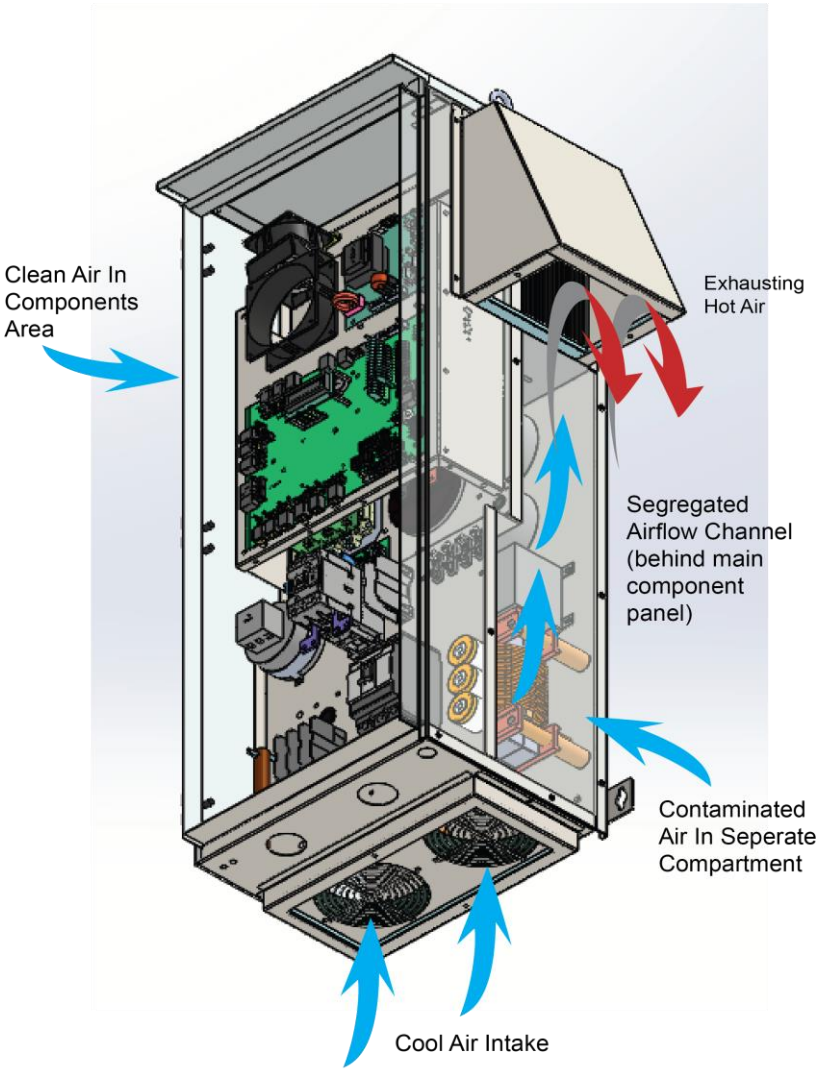


However, our enclosures feature a specially engineered duct system in the back section of the VFD, effectively dividing the VFD enclosure into "clean" and "dirty" air compartments.

All sensitive electronic components are housed in the front section, away from any contaminants in the outside air. The cool outside air flows

through the heatsinks in the back compartment and across the internal magnetics, which are some of the hottest components in the VFD.

With this unique hybrid system, Phase Technologies' VFDs are able to cool consistently and efficiently in the hottest and harshest environments, while maintaining a simple and cost effective design which is easily serviceable if failures arise.



Final Conclusion

Most VFD manufacturers incorporate one of two basic cooling schemes in their outdoor enclosures and each cooling method has unique advantages and disadvantages. Direct cooling methods are very cost effective but expose sensitive critical electronic components to external contaminants, leading to premature and expensive failures.

Indirect cooling methods such as air conditioning, copper heat pipes, and water cooling are more effective at cooling and keeping contaminants away from critical electronic components; however, the major disadvantage to these systems is that they are cost-prohibitive, both on the initial installation and with on-going maintenance and repairs.

The unique, indirect hybrid cooling method developed and integrated by Phase Technologies combines the best from both cooling approaches. Our unique methodology combines the cost-effectiveness of direct cooling with the contamination-limiting benefits of indirect cooling. By using outside air as the cooling medium in a compartmentalized enclosure design, our approach offers unique, affordable solution while mitigating the risks contaminated air poses to sensitive electronics located within a VFD.

About Phase Technologies

Founded in 1999, Phase Technologies developed Phase Perfect® Digital Phase Converters, the first major advancement of phase conversion technology in decades. Recognized as the world's leading manufacturer of phase converter technologies, the company expanded its product offerings to include variable frequency drives (VFD's).

Specializing in VFD with Active Front End technology, Phase Technologies produces the only low harmonic, fully regenerative, phase-converting VFD that complies with IEEE 519, the international standard for allowable harmonic levels on utility mains. The company has an extensive product line-up of low harmonic, fully regenerative drives in both three-phase and phase-converting models.

Phase Technologies relies on a team of in-house power electronics and mechanical design engineers to develop innovative products, encompassing all aspects of hardware and firmware design. All products are manufactured at our facilities in the USA under exacting quality standards. In-house processes include printed circuit board population and custom magnetics fabrication.

The company operates a certified UL 508A panel shop to integrate our drives into rugged outdoor panels with custom options for applications including irrigation, oil and gas production and general industrial control.

Integrity and honesty are the cornerstones of customer interaction at Phase Technologies. Knowledgeable sales experts are available to help customers select the right product to fit their needs, and we partner with the best distributors and dealers to make our products available with rapid delivery times and local service. Experts in our customer service department are standing by to answer technical questions and provide the support to keep your application up and running.

For more information, visit www.phasetechnologies.com

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