



THINGS EVERY HEAT PUMP MANUFACTURER SHOULD KNOW ABOUT THERMAL CONTROLS

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Believe it or not, the recent pandemic turned out to be an effective tool in the fight against climate change. Apparently, a number of scientists with time on their hands decided to solve the problem heat pumps often encountered in cold weather. As a result heat pump sales have skyrocketed and become a valuable tool in the effort to lower fossil fuel emissions. Its a good thing they worked on these problems because new governmental standards and regulations have been difficult to meet using more traditional furnace and air-conditioner-based HVAC systems.

This Whitepaper should be read by:

- » Design engineers working on heat pump designs and improvements.
- » Executives at heat pump manufacturing companies.
- » Manufacturing engineers at heat pump manufacturing companies.
- » Independent design engineers
- » Product designers
- » Purchasing managers at heat pump manufacturing companies.
- » Anyone who values reliability in HVAC product design and manufacturing.

This Whitepaper will explain:

- » Why heat pump regulations have placed a premium on reliability.
- » How you can improve the reliability of electrical circuits in heat pumps.
- » How to gauge how reliable a thermal control will be in heat pump applications.
- » How some simple customization steps can help you improve heat pump reliability.
- » How to deal with logistical problems inherent in heat pump designs.

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During the pandemic, a number of product designers and research scientists decided to tackle a difficult problem. They knew heat pumps were a more sustainable and energy-efficient way to heat and cool homes in moderate climates. New regulations were pushing homeowners to use them in their homes. However, they did not deliver enough heat in colder climates or enough cooling air in hot climates. The solutions they developed were both ingenious and practical leading to unprecedented growth in heat pump sales. However, these changes also put a strain on the electrical circuits used in heat pumps. Reliability concerns centered on the design and manufacture of thermal controls used as safety devices in these circuits. This white paper takes an in-depth look at ways to increase the reliability... and safety... of electrical circuits used in the manufacture of heat pumps, worldwide.

Why HVAC Changes are Happening so Fast

Under recent changes to climate and environmental regulations, traditional HVAC systems will become obsolete and be replaced by more efficiently engineered systems to meet the new standards and regulations. Entities like REACH and RoHS are now requiring tighter emission controls from systems using fossil fuels for energy. New US regulations from the US Department of Energy (DOE) have established certification, compliance, and enforcement in the CFR at 10 CFR Part 429. The new standards that went into effect in 2023 require a seasonal energy efficiency ratio (SEER) of no less than 14 SEER for residential systems in the northern part of the United States and 15 SEER in the southern part of the United States.

The 2022 Energy Code encourages efficient electric heat pumps, establishes electric-ready requirements for new homes, while expanding solar photovoltaic and battery storage, ventilation standards, and more.

On Jan. 1, 2023, new minimum efficiency standards for air conditioners and heat pumps went into effect across the United States.

These new standards and regulations affect HVAC design engineers, HVAC System manufacturers, component suppliers, HVAC contractors and ultimately the end user.

New heat pump engineering advancements enable these new standards to be met, even in the coldest and hottest places. However, continuous loop heat pump systems put a premium on the performance characteristics of component parts. Davidon Industries, an engineering firm in Rhode Island works with a number of component manufacturers, including Portage Electric Industries. Recently Adam McKnight of Davidon and Ted Monty from Portage Electric talked about the special needs of heat pump manufacturers and how component suppliers can help them improve the reliability of their systems while meeting current and future climate and environmental regulations. This white paper was developed from those conversations.

Overview

Because heat pumps provide an air transfer loop between condenser, compressor and evaporator, they operate almost continuously, with far fewer stops than traditional furnaces and air conditioning systems. They also operate in both refrigerant and heater mode, putting different stresses on the system than a traditional HVAC equipment experiences. As a result, they require somewhat more robust components, especially moving parts and electrical circuits. Circuit safety components such as resettable thermal controls and thermostats are susceptible to wear damage due to constant recycling. To prevent catastrophic failure heat pump manufacturers are urged to consider three key ingredients in the design of the thermal controls they use:

1. Contacts used to close circuits should be designed to prevent tarnishing and misalignment that could prevent a circuit from fully closing.
2. Thermal controls, especially those used as high temperature controls should be shielded from ambient heat build-up that could cause premature tripping.
3. Since there are a variety of different heat pump products and each manufacturer's designs are different, thermal controls should be customized in a number of ways to ensure maximum performance efficiency and reliability.

This white paper will take a closer look at each of these considerations and show you how to gauge the potential efficiency and reliability of the thermal controls you use in your heat pump designs.

Why Electrical Circuit Reliability is so Important to Heat Pump Manufacturers

Liability and reputation are important considerations to any manufacturer, but especially to those whose products are critical to the comfort of any home. Unlike furnaces and air conditioning units that operate seasonally, heat pumps operate continuously so they may have frequent stop/start cycles. Wear on components is a greater threat and a circuit malfunction could lead to rapid heat build-up which could, ultimately, wind up causing severe damage to homes with potentially life-threatening consequences.

Efficiency gains, as well as advances in refrigerant technology, have moved heat pumps from the luxury market to more mass markets. As a result manufacturers are facing increasing pressure to manufacture more efficiently while still maintaining strict safety and reliability levels. By customizing thermal controls to make the activating bimetallic elements more in tune with application needs, heat pump manufacturers can more easily walk the thin line between cost and reliability.

There are also three major types of compression heat pump systems currently being manufactured:

1. Water Source
2. Air-to-Air.
3. Geothermal.

Each uses a variety of safety mechanisms, including thermal controls to ensure efficient operation within selected temperature ranges and prevent overheating in electrical circuits. The existence of different circuitry in heating, cooling and defrost systems can create logistical problems for manufacturers trying to maintain reliability standards while meeting budgetary concerns. Portage Electric Products, Inc. (PEPI) is one of the few, if not the only, thermal control manufacturers to offer virtually every type of thermal control from one-shot thermal fuses to various designs of cantilever bimetallic controls and 1/2" disc-type controls. This is the result of their purposeful product design strategy targeted at simplifying procurement for customers worldwide.

How to Ensure Circuit Reliability

Thermal controls provide both the key operating and safety mechanisms for electrical circuits on both the compressor and blower side of heat pump systems. However, continuous operation in differing environmental conditions can stress the performance profile of any device used to open and close circuits perhaps hundreds of times a day. One miss and catastrophic failure occurs.

Pay attention to the ability of contacts to resist oxidation

The easiest way to predict reliable functionality is delve into the quality of the raw materials used in the manufacture of a particular component. When it comes to resettable thermal controls there are two main components to look at: Contacts and the bimetal wing used to make and break circuits as circuit temperatures rise and fall.

Most manufacturers use some form of silver contacts due to silver's excellent conductive properties, but it's the details that count. The type of silver matters because some grades of silver are more susceptible to oxidation and, therefore, more likely to tarnish than others. Oxidation impedes the flow of electrical current through contacts, robbing them of reliability.

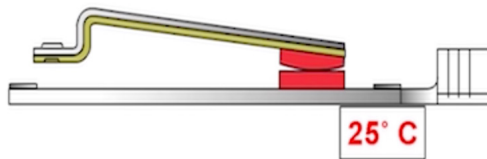
Silver alloys that have copper, zinc or nickel are more prone to oxidation. The quality of the silver also matters. As is true of all components, there is a delicate balancing act between cost and performance. Coin-quality silver, deemed to be 90% pure silver maintains this balance most effectively. By diffusing coin-quality silver with gold

creates an alloy uniquely capable of resisting oxidation and maintaining a reliable flow of electricity through the circuit when contacts are closed.

Determine the chances of contact misalignment

Whether through variation in the manufacturing process or wear caused by normal usage, contacts can suddenly find themselves misaligned. Misalignment occurs when contacts only partially touch when the closed. This can either weaken or impede the flow of current through the circuit.

You can judge the potential for misalignment by viewing both the size and shape of contacts used in any particular thermal control. Disc-shaped contacts are cheaper and easier for thermal control manufacturers to install, however their shape limits contact to single edges causing a weakened flow of current. Slightly rounded contacts make better contact with more surface area, however size is a critical determinate of future reliability.



Over-sized, slightly rounded contacts provide the most contact surface area and the best safeguard against problems caused by misalignment.

Customize to more precisely match application requirements

The average heat pump system includes between 15 and 25 different thermal controls between the compressor and blower sides of the system. Each system is also finely tuned to separate as much heat or cool as possible from outside air. Buying off-the-shelf thermal controls are a good way to ensure the kind of mediocre performance and unreliability heat pump manufacturers can't afford. Better to make sure your thermal controls are precisely tuned to the performance and manufacturing needs of a particular heat pump system.

When considering customization options, it's best to start by specifying bimetal thermal controls since they are easier to fine tune to match application needs. These thermal controls are available in both cantilever and disc type configurations with bimetal wings used to make and break circuits as different metals on opposite sides react differently to heat and current conditions, bending one way or the other. Since there are a virtually unlimited number of bimetals available, a bimetallic thermal control can be tuned to any particular application by changing the bimetal used to create the wing.

Cantilever and disc-type thermal controls can also be customized to isolate them from ambient temperatures that may affect performance, as well as environmental considerations such as liquids or humidity. These type of customizations are especially popular in heat pump applications.

One of the most popular customization options is used to trim manufacturing costs by having lead wires attached before shipping to a factory manufacturing heat pumps. Any type of lead wire can be attached in virtually any length to simplify heat pump manufacturing operations.

The Logistical Nightmare Caused by Combined Heating and Cooling Cycles

No HVAC system is simple, but heat pumps are certainly more complex than traditional furnace and air conditioning systems. Heat pumps not only contain both heating and cooling cycles, but also the reversing valves and defrosting boards necessary to combine both systems into one. Of course, there is also the emergency heating cycle required to ensure comfortable operation in extremely cold environments.

This complexity and the need for reliable operation means a variety of different thermal controls are used in every heat pump system. Many of these appear at critical points in the system, including on the circuit operating the critical reversing valve. In addition, critical components such as the electric strip heaters require resettable high temperature controls with thermal fuse back-ups to guard against catastrophic heat build-up. The combination of higher and low voltage wiring adds to the wide range of thermal controls required to keep a heat pump system operating efficiently and safely.

As a result, a heat pump manufacturer can easily find themselves sourcing controls and thermal fuses from a variety of sources with differing reputations for reliability.

The Portage Electric Products, Inc. Solution

Over 25 years ago, Portage Electric Products, Inc. embarked on a supply line program to make it easier for manufacturers to get any type of thermal control from a single source. Through expansion of their global manufacturing and warehousing base, as well as critical key global vendor alliances, PEPI thermal controls are now available in every configuration and customization option needed by heat pump manufacturers worldwide. For more information contact, pepsales2@pepiusa.com, or call +330-499-2727 or toll-free 888-GO4-PEPI (888-464-7374)

The Davidon Industries/Portage Electric Solution

Over 25 years, Davidon Industries and PEPI® have embraced a strategic partnership to make it easier for manufacturers to get all the HVAC controls they need from a service-oriented single source. This supply chain program includes a global network of manufacturing and warehousing locations dedicated to making superior, highly-engineered assemblies, components and parts readily available. With their key global alliances, Davidon Industries and PEPI® can offer every configuration and customization option needed by heat pump manufacturers, worldwide.

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