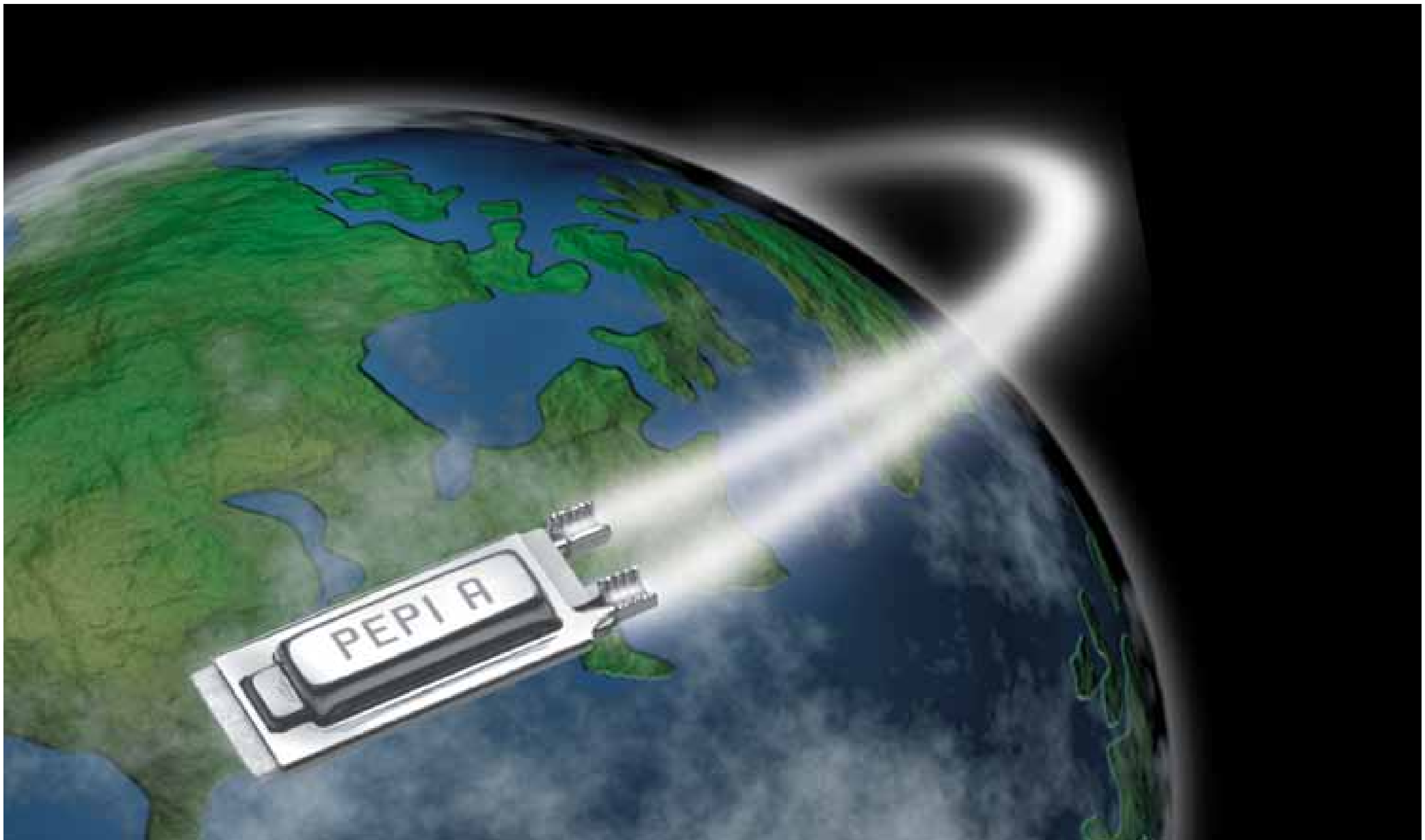

Derating For Real World Conditions

Allowing for desired safety margins when selecting components of an electrical circuit requires close attention to how each component will react to real world conditions, both ambient and circuit-related.

This Whitepaper will explain:

- » Why thermal controls function differently in real world conditions.
- » How to anticipate the amount of derating a device will experience in a particular application.
- » How specifying a different bimetallic element will easily improve performance in your particular application.
- » Why derating will improve the safety of your products.

This Whitepaper should be read by:

- » Design Engineers of consumer appliances with electrical circuits requiring protection afforded by re-settable thermal controls.
- » Design Engineers of automotive products that utilize electrical circuits requiring protection afforded by re-settable thermal controls.
- » Designers and manufacturers of battery packs
- » Designers and manufacturers of small motors used in various products.
- » Designers and manufacturers of lighting products.
- » Prototype Engineers charged with testing and selecting thermal control devices.

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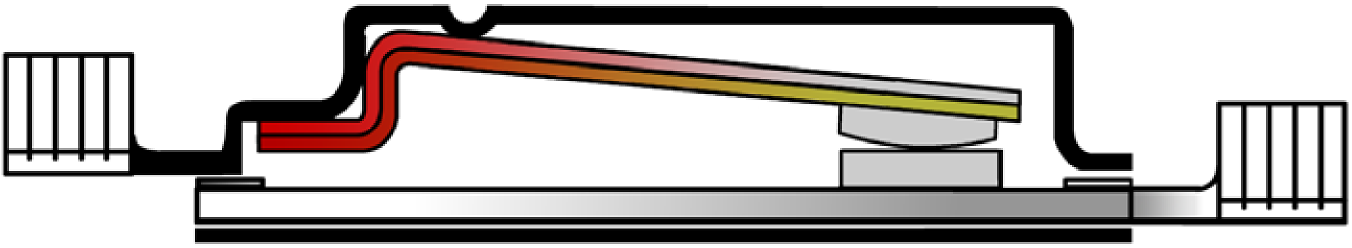
Conductive-type thermal controls provide for the safe operation of an electrical circuit while allowing for complexities of circuit design. These devices incorporate a bimetallic element into the circuit so that the thermal control reacts to both changes in current and ambient temperature, enabling the device to open (break) at a pre-set temperature. Since conductive controls carry circuit current they add another degree of protection beyond the ability to react to changes in ambient temperature. However, this added level of protection must be accounted for when applying conductive-type controls into your application. The resistance value (resistivity) of the bimetal element causes heat build-up that can lead to opening the circuit at lower temperatures. In other words, the device is operating at a lower temperature rating than expected. This derating effect must be acknowledged and accounted for in every design application. However, it provides an extra, often critically-important, margin of safety by getting circuits off-line before there is a dangerous build-up of heat.



The higher the resistivity of the bimetal the greater the heat build-up.

Resistivity of Bimetallic Elements

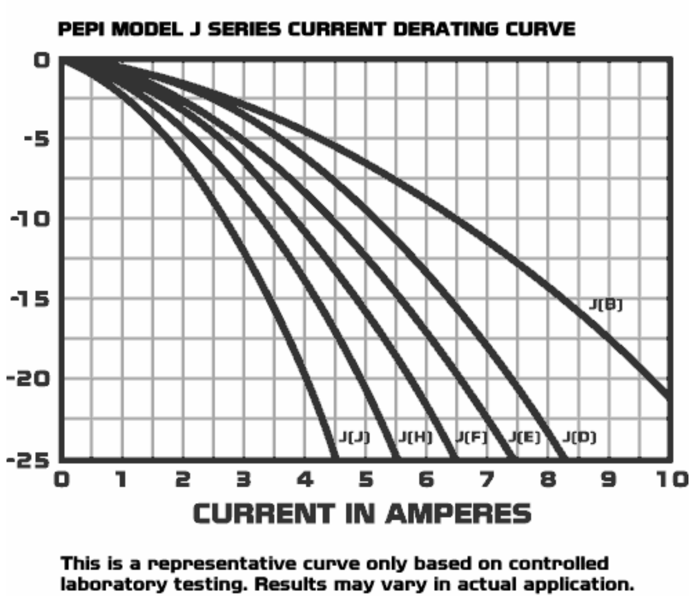
Resistivity is a measure of how strongly a material opposes the flow of electric current. A low resistivity material, such as silver, readily allows the flow of current in an electrical circuit. A material with higher resistance, such as nickel, impedes the flow of current in the circuit generating heat in the process.

One of the functional attractions of conductive-type bimetallic controls is the ability to match the sensitivity of the bimetallic element to the functional needs of the application. There are a wide variety of bimetallic elements that can be used in conductive-type controls when incorporated into an electrical circuit. By altering the sensitivity of the bimetallic element, a designer can make the device either more or less sensitive to current flowing through the circuit and ambient temperatures surrounding the device. The sensitivity of the bimetal is actually a measurement of the resistance different metals exhibit to current flowing through them. The more sensitive the element, the higher its resistivity. This is similar to the higher water pressures that build up in smaller diameter hoses as opposed to larger diameter hoses.

This resistivity causes a self-heating effect in the bimetal element, known as I^2R effect. Basically, the I^2R effect is the amount of heat generated due to power losses when current flows through the bimetal. The measurement of this lost power indicates how freely or how impeded current flows through the various types of bimetal. Low resistivity elements experience lower I^2R heat effect. High resistivity elements exhibit more I^2R effect. This self-heating characteristic plays a prominent role in derating the performance of a thermal control and is especially useful when thermal controls are utilized in inductive load applications.

The design objective is to anticipate heat build-up in a circuit and shut it down quickly and before catastrophic failure can occur. This is made easier by derating which anticipates how a device will behave in conditions closer to those in the real world.

Typical Derating Curves



What is Derating?

Current derating is a term used to describe the self-heating effect of a thermal control based on the amount of current flowing through the device. Derating is a measurement for current-carrying devices to react (open) at a temperature lower than its preset operating temperature. This is due to the I^2R effect or internal heating of the bimetallic element. The amount of deration for each type of device is expressed in derating curves that provide general guidelines to define anticipated functionality under various electrical loads. In this manner, derating increases the margin of safety between design limits for applications that are subject to unanticipated increases in electrical loads.

Starting Points vs. Operational Characteristics

All manufacturers of reliable thermal controls have had their products evaluated by one or more world-wide safety approvals agencies to standards based on the specific needs of the end application. These evaluations permit manufacturers to provide contact ratings expressing the maximum allowable voltage and current that it can carry, or pass through the device. When the load flowing through a circuit exceeds the rating of the thermal control tasked with protecting the circuit, it will open to prevent a catastrophic failure. However, for certain application types, the stated ratings do not take into account real world operating conditions.

It is important to note that both ratings and anticipated deratings are derived from lab testing under controlled test conditions. True real world effects from actual loads, ambient temperatures, cooling mechanisms and placement of the device can only be measured in actual application testing.

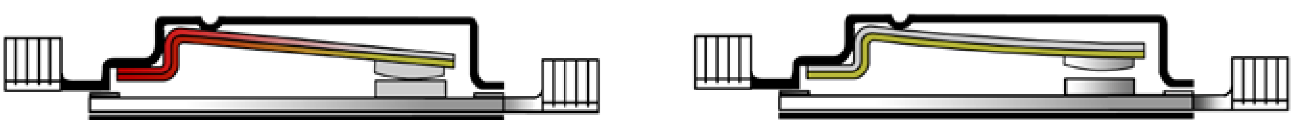
Using Derating to Your Advantage

The ability to utilize the effects of derating to help anticipate real world fault conditions helps product designers maintain a margin of safety. Consider a typical sump pump motor carrying an inductive load. In inductive load applications, there is a high potential for the current to increase sharply … even faster than the temperature. This can occur if a sump pump would lose its prime and the normal resistance is removed as water stops flowing through the pump. All of a sudden the motor speeds up and heat builds up fast. By placing a thermal control in the circuit, it can anticipate rapid heat-build up and get the circuit off-line even before ambient temperatures become hot enough to trip the device. You can observe the same phenomenon by placing your hand over the suction hose of a vacuum cleaner and listen to the increase of the speed of the motor.

The window between a product's normal operating state (steady state) and full load current, (safe maximum limits) is the area where a product designer can utilize the derating effects of thermal controls to plan for safe operating performance. Once the operation of an application surpasses that window it must be taken off line as quickly as possible. The key is to have a current carrying device in the circuit that senses increases to the electrical load even before there is an unsafe increase in temperature of the application.

Low Resistance vs. High Resistance Bimetals

As mentioned previously, an advantage of bimetallic devices is their ability to match their performance with application needs. Some applications, such as battery packs, require less sensitive devices that allow current to flow virtually unimpeded. Lower resistance devices do not exhibit the I^2R self-heating effect and present a truer relationship between the fixed set point of thermal control and the actual temperature of the battery pack it is protecting. In an application like a battery pack, a thermal control with higher resistivity would actually draw more power out of the battery causing the battery to discharge at a faster rate than what would be considered optimum.



The more sensitive the bimetal, the more quickly the circuit will be opened

Thermal controls with higher resistivity are required whenever it is desirable to pick up changes in the electrical load, most often prior to a build-up of heat in the application. As mentioned previously, these conductive devices actually combine the performance of a temperature sensitive device with that of a circuit breaker to anticipate problems and get motors off-line quicker than a device operating solely on changes in ambient temperature. In some applications, it is critical to have a device which interrupts the electrical circuit far sooner than a non-current sensitive device would function based strictly on increases in the ambient temperature. Without this anticipation of the thermal control, some materials used in the application could degrade, or even worse, fail.

Selecting the Right Bimetal for Any Application

Selecting the right bimetal materials is a critical factor in determining how a thermal control will perform in your application. It is essential that thermal control manufacturers offer design engineers a choice between different bimetallic elements to enhance performance of the thermal control under certain application conditions, especially when providing optimum operating performance and safety considerations for inductive type loads.

Conductive type devices derate as loads build. Understanding this tendency to derate can be helpful to the design engineer because it provides a surer view of the safety window that extends from the steady state to full load current.

However, the design engineer must always remember that both ratings and expected deratings for different bimetals and thermal control devices are done under laboratory environments with no-load conditions.

This is where Portage Electric's unique ability to work as a design partner comes into play. We are an engineering-oriented company with nearly a half-century of experience working with virtually any bimetallic combination and can recommend the right device and bimetallic element to use for any application. However, after selecting the device most likely to match your application needs, you must also test on your application to make sure it is the correct device for your particular application.

“WE COME THROUGH WHEN THE HEAT IS ON®”

Most of our customers are facing demands to do more in smaller spaces, on tighter budgets and in less time. Our versatile manufacturing processes and substantial engineering capability helps them meet these challenges. We can manufacture and deliver small to large quantities of thermal controls customized to better fit particular customer requirements. Our dedicated Prototype Lab is set up to quickly design, manufacture and deliver sample devices for customer testing. Portage Electric Products is the place to turn for high value, high-reliability thermal controls because “We come through when the heat is on®”.

DESIGN CONSIDERATIONS

Certain aspects should be taken into consideration when applying these devices. Careful attention must be paid to input voltage, load currents and the characteristics of the load. Final design criteria should be based upon results of your testing of our devices in your application at your facility.

HOW TO GET WHAT YOU WANT

Our wide range of standard products are found in this catalog. Should your application require a device not found here, feel free to call. Our Prototype Department is skilled at finding answers to special needs, fast.

SAMPLES

Should you require samples for your application testing, please complete the Sample Request Form found on our website: www.pepiusa.com. If you are unsure which of our models to use in your application, please feel free to contact our Sales Department for the necessary information, and we will gladly suggest a model for you.

TECHNICAL ASSISTANCE

We are happy to provide customer assistance and technical advice in a variety of areas. We appreciate the opportunity to assist you and to better understand your needs. However, since Portage Electric Products does not possess full access to data concerning all of the uses and applications of customer’s products, we cannot assume any obligation or liability for information we provide, or for results you might obtain.

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