

PTC Heaters Guide

A Quick & Easy Guide to Safer, Faster, and More Uniform Heating Solutions

Overview

PTC heaters are flexible, printed, self-regulating heaters. Instead of using coils, wires, or carbon fiber materials typically found in traditional heaters, they use conductive inks printed on polymer-based substrates. This technology evenly heats across the entire surface of the product and self-regulates to a designed temperature, which eliminates the possibility of overheating. PTC technology is a must for products that require safer, faster, or more uniform heating.

This brief guide will answer all your burning questions - what, why, and where of PTC heaters. It will also equip you with design technical considerations and help you determine if PTC heaters are right for you.

INTRODUCTION

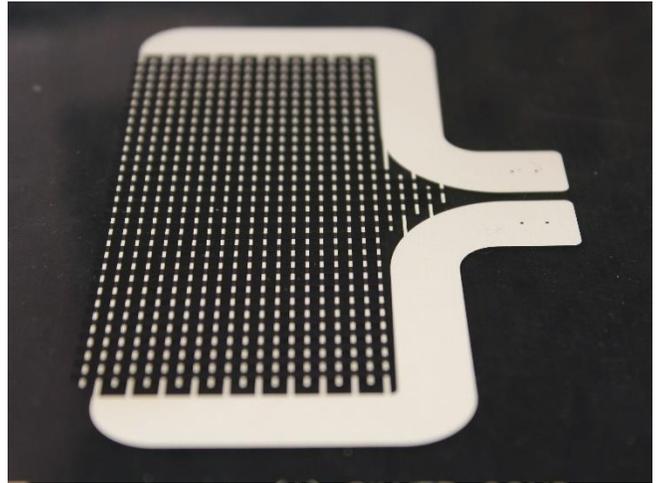
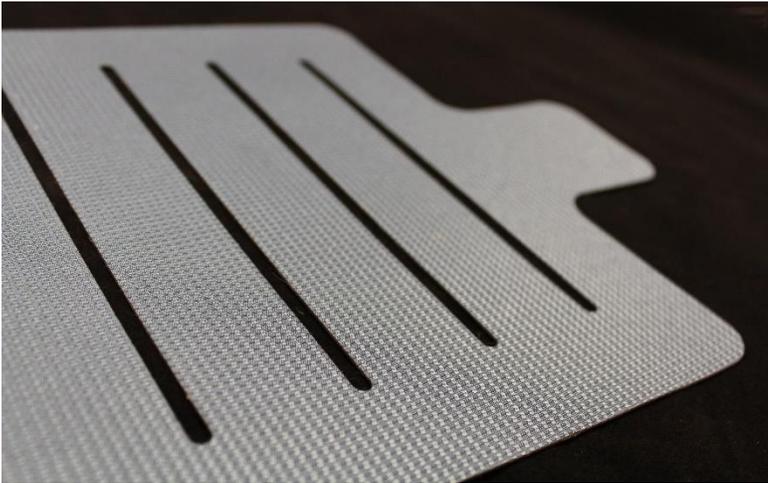
Resistive heating is the process of converting electricity into heat energy. Fixed wattages, commonly used resistive heaters, are typically manufactured with resistive wires or etched circuits. Like the principle used in a toaster, the wire in a fixed wattage heater must reach a very high temperature to dissipate the desired temperature across the area to be heated. To keep the heater from overheating, a thermostat or temperature sensor is used. This single point sensing method remains one of the crucial problems with fixed wattage heaters. Any failure with the sensor or the circuit can lead the heater to reach dangerously high temperatures, thus becoming hazardous to the user. Furthermore, the heater will continue to draw power if the malfunction is not detected by the temperature sensor. Other failure modes associated with fixed wattage heating include hot spots, broken conductors, and overheating.

Fortunately, we can overcome all these issues with self-regulating PTC heating elements. Their inherent safety allows for the smooth operation of the heater without any sensors or thermostats. Additionally, the end-product runs more efficiently, producing energy savings. This brief guide is designed to answer all your questions and help you determine the feasibility of PTC heaters for your unique application.

WHAT ARE PTC HEATERS?

Positive Temperature Coefficient (PTC) heaters are self-regulating heaters that run open loop without any external diagnostic controls. While traditional fixed-resistance heaters employ wires and coils to generate heat,

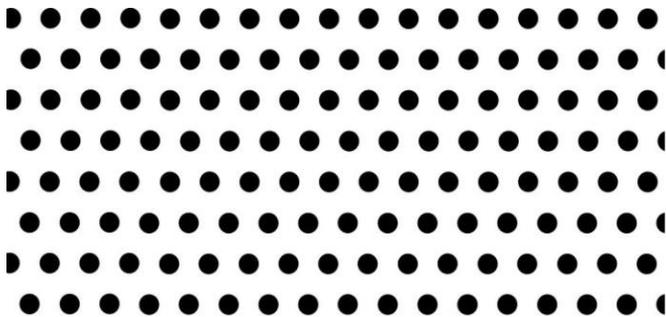
PTC heaters use conductive inks printed on thin, flexible polymer-based substrates. Scoring high on reliability and efficiency, they are ideal for products that require safer, faster, and more uniform heating. The material properties allow the PTC heater to act as its own sensor, eliminating the need for any external feedback controls. As a result, the heater inherently eliminates the risk of overheating.



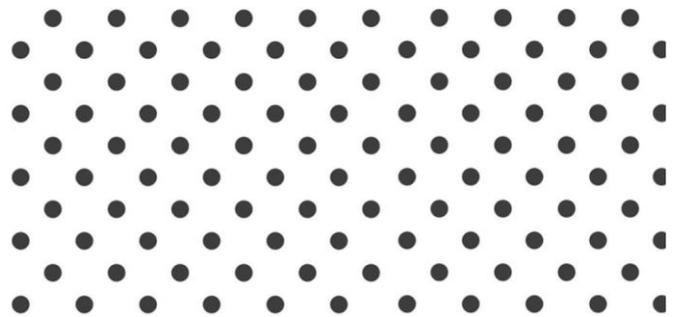
Custom PTC heaters printed and manufactured at Boyd

WORKING PRINCIPLE BEHIND PTC HEATERS

PTC heaters utilize Positive Temperature Coefficient materials i.e., materials that exhibit a positive resistance change in response to the increase in temperature. As the temperature increases, the electrical resistance of the material also increases, thus limiting the current flow. Simply put, the material allows current to pass when it's cold and restricts current to flow as the threshold temperature increases.



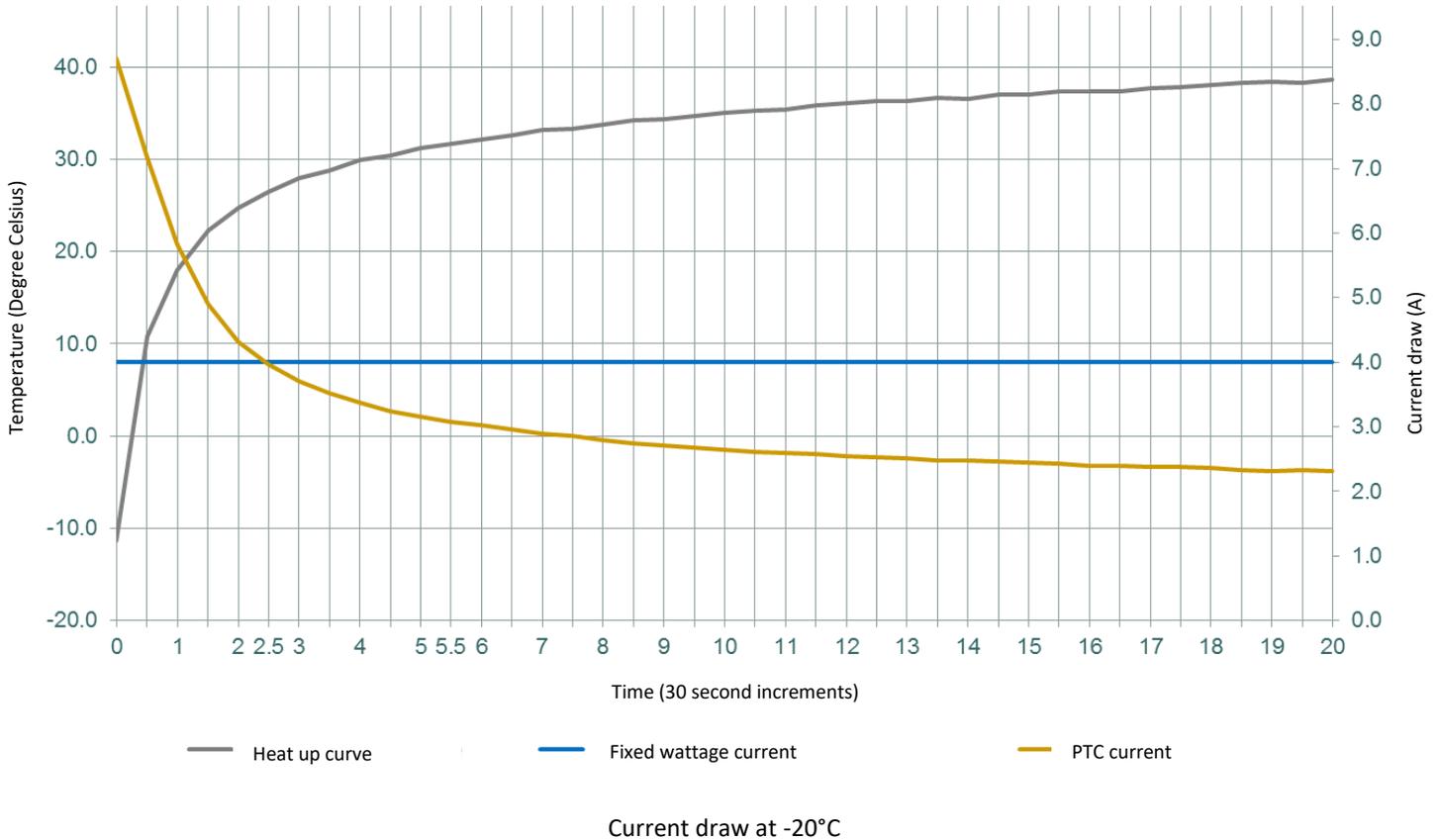
Carbon molecules in low resistance state



Carbon molecules in high resistance state

PTC heaters draw full power initially to quickly heat up and reach the optimum temperature. As the heat increases, the power consumption simultaneously drops. This dynamic heating system is not only effective but

also time and energy efficient. PTC heaters ramp up faster than fixed wattage at cold temperatures, saving energy over run time.

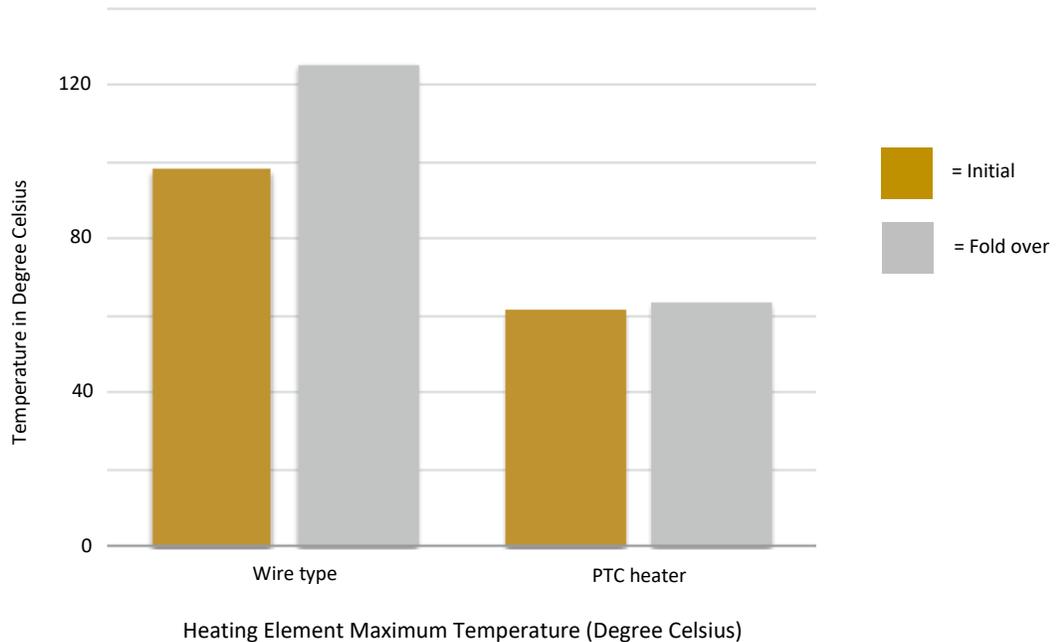


Materials and Properties

With a striking blend of performance and functionality, conductive inks are energizing the success of printed electronics, such as PTC heaters. They give you the freedom to cost-effectively design intricate heating patterns and enable streamlined large volume production.

With PTC heaters, carbon conductive inks are screen printed on polymer-based substrates. While polyester is primarily used, other substrate materials can also be utilized. The PTC conductive inks can endure repeated cycles of heating and cooling. The printed circuits are sealed with an adhesive laminate to prevent the ingress of moisture.

PTC heaters can withstand mechanical abuse such as bending and piercing and are also resistant to chemicals and abrasion. While a fold-over in a traditional wire heater can cause excessive and potentially dangerous temperature spikes, PTC heaters run cooler than comparable wire heaters and are minimally affected by fold-overs. They can withstand extreme external conditions and survive the rigors of heavy usage.



Design and Technical Specifications

PTC heaters can be designed to operate up to 75°C (167°F). The threshold temperature is customized during the design phase and designs with multiple temperature zones are also achievable. The heating system can run at different voltage levels ranging from 5V to 120V. The maximum watt density supported is 1.2 W/sq.in. Watt density can be changed through simple design alterations and multiple watt densities are also possible on a single heater. Pulse Width Modulation (PWM) can be utilized to achieve multiple heat output settings.

Typically, a PTC heater is supplied with a 0.110" quick connect that is dual riveted to the circuit, and then the circuit is completely sealed from the opposite side. Any wire with a mating connector can be assembled to the heater. PTC heaters are thin and flexible. Typical thicknesses are 0.005" – 0.010", depending on the design criteria, and the need for mounting adhesives or other structural layers. They can be daisy-chained in parallel for larger surface areas.

BENEFITS OF PTC HEATERS

Meeting at the crossroads of safety and efficiency, PTC heaters provide more uniform heating than traditional heating technologies. Their inherent self-regulating nature results in fewer field problems and lowered warranty costs. The sealed construction prevents ingress of moisture and dust.

Below are ten advantages of PTC heaters as compared to traditional fixed-resistance heaters:

- 1) **Improved Safety** - PTC heaters eliminate out all the failures and shortcomings associated with wires, etched foils, and carbon fiber heaters. The PTC material acts as its own sensor, thus eliminating the risk of overheating.
- 2) **Uniform Heating** - Every point on the heating surface independently maintains its designed temperature. The even distribution of heat leaves behind no hot and cold spots. Unlike wire heaters, PTC heaters are minimally affected by folds and do not overheat.
- 3) **Lower Power Consumption** - PTC heaters draw full power at colder temperatures to quickly reach the threshold temperature. Once they reach a steady state, they consume less power than traditional heaters, eventually saving more energy over the entire run time.
- 4) **Better Strength and Durability** - PTC heaters can endure mechanical abuse such as folding, creasing, and piercing. They are also resistant to water, chemicals, and corrosion, resulting in superior durability and prolonged life.
- 5) **Design Flexibility** - PTC heaters can be produced in unlimited shapes and sizes, with custom holes and cutouts. They can be connected in parallel for large-area heating requirements. They can also be custom designed to operate with multiple temperature zones and wattages.
- 6) **Faster Time-to-Temperature** - The optimum temperature is achieved in a very short period. At cold temperatures, PTC heaters ramp up faster as compared to traditional fixed-resistance heaters.
- 7) **Fail-safe** - Any failure will 'fail to cold', rendering them harmless. The failed portion will simply stop drawing more current, and the rest of the heater will continue to function safely. The PTC heater will fail cold when punctured, torn, or cracked.
- 8) **No Electronic Controls** - The heater self-regulates to its designed threshold temperature, thus wiping out the need for any diagnostic components or external control units. It combines two features into one: it serves as the heating element, and it acts as its own temperature sensor.
- 9) **Lightweight and Thin** - PTC heaters can be as thin as 0.005", taking up little space. Their thin construction makes them extremely lightweight and are more flexible than silicone heaters.
- 10) **Environment-friendly Manufacturing** - While the subtractive manufacturing of etched-foil heaters requires acid baths, the manufacturing process of PTC heaters does not produce or involve any hazardous chemicals.

Advantages of an Open Loop Heater

Open-loop heaters are heaters that do not require any external diagnostics like a thermostat. A thermostat turns a heater on and off when it reaches a high or low temperature. Many factors affect the accuracy of a thermostat such as improper installation, deposition of dust, corrosion, placement of the thermostat unit, age, and factory defects. Improper reading could lead to overheating or a non-functional heater. Additionally, this method of single point sensing does not take into consideration the temperature of the rest of the heater. The thermostat "assumes" that the rest of the heater is functioning at the same temperature as the single measured point. PTC heaters eliminate this issue by acting as its own temperature sensor. In fact, the entire heater acts as the sensor, thereby putting a lid on erratic temperature fluctuations.

APPLICATIONS OF PTC HEATERS

PTC heaters are self-regulating, energy-efficient heaters that provide uniform heating. They have survived the rigors of the automotive industry for decades. By thriving in an industry marked by extreme environment and tough conditions, PTC heaters have proven their robustness and reliability. From car seats to surgical tables, they are well-suited for a wide range of applications across several industries such as:

- **Transportation (eMobility, Automotive, and Aerospace)** - In the automotive industry, PTC heaters can be used to improve the heating within the vehicle with applications including seat heating, battery thermal management, LDW (Lane Departure Warning) camera and sensor de-icing, steering wheel heating, and rear-view and side mirror heating. They can be effective seat warmers in all kinds of transportation vehicles - cars, RVs, buses, trucks, golf carts, UTVs, ATVs, agricultural tractors, cranes, and even boats. Since PTC heaters can operate with less power than traditional heating technologies, the vehicle's battery life is maximized. PTC technology offers ease of integration for in-flight applications, making it a great choice to warm anything in the cabin like the seats, walls, or floor panels.
- **Medical Healthcare** – The safety of patients are of paramount importance in the Medical industry. PTC heaters are ideal for under-body heating solutions such as human and veterinary surgical tables, veterinary and patient beds, gurneys, and even over-body blankets and drapes. They can be used in dentist chairs, clinic chairs, and mobility vehicles (e.g., wheelchairs and mobility scooters). They are suited for physical therapy heat pads used to reduce muscular and joint pain. The uniform heat and low power consumption make PTC heaters suitable for fluid warming applications such as infusion pumps. PTC heaters are safe for direct contact with the skin and can also be used as a peel-and-stick patch.

While most drugs are stored at controlled room temperatures, the drop in temperature during winters can adversely affect medicines. Even shipping medications during cold spells can pose significant challenges. Since PTC heaters can be customized to operate at a threshold temperature, they can be successfully used in fluid warming cabinets, drug storage, and shipment solutions, etc.

- **Recreational and Outdoor Clothing** - PTC heaters are perfect for “people-heating”. The ability to run open-loop (without electronic controls) and their lightweight make them ideal for outdoor recreational jackets and vests. During the winters, PTC-heated jackets can provide warmth and comfort to construction and maintenance workers, traffic controllers, agricultural workers, and other people who spend a considerable amount of time outdoors.

PTC heaters are more energy-efficient than the alternative technologies available today. They operate flawlessly in extreme environments and adapt to the shifts in temperature. PTC heaters offer great design flexibility in terms of shapes and sizes. They are well suited for mass production and can be integrated in a wide array of products like commercial bedding, food warming and storage solutions, rescue stretchers, outdoor venue seating, and military jackets.



Applications of PTC heaters

THE BOYD ADVANTAGE WITH PTC HEATERS

As a vertically integrated custom manufacturer of flexible electronic circuits, Boyd has vast experience in printing conductive inks. Our PTC competencies encapsulate everything from heater design, reel-to-reel printing, application engineering, to final testing. But why should you put your trust in Boyd?

- **Experience** - Boyd brings together 90+ years of custom-manufacturing experience across a wide array of industries including medical, aerospace, and automotive. More than just experience, Boyd has state-of-the-art equipment and technology to tailor unique solutions for all your heating needs.
- **Expertise** – Boyd’s PTC experts not only have decades of first-hand experience with printed electronics but also hold several patents in the PTC technology field. Our PTC engineers’ core strength lies in the knowledge and understanding of how to integrate PTC technology into your application. This extensive application experience results in a better performing heater for your product.

- **Robust Quality System** - As an ISO 9001-certified company, our strict processes and quality controls allow us to produce PTC heaters with more uniformity and tighter temperature tolerances.
- **On-site Testing** - Thanks to our on-site thermal analysis capabilities and environmental testing equipment, the PTC heaters rolling out of Boyd facilities are stable and uniform.
- **Environment and Compliance** - Boyd is committed to preserving the environment. We exceed governmental standards and maintain a voluntary pollution prevention plan that has delivered impressive reductions in energy and waste. We are also DRC conflict-free and REACH, RoHS compliant.

WHAT'S NEXT?

No matter what your PTC needs are, Boyd has the solution. Our PTC heaters are custom designed to meet your specific requirements in terms of shapes, sizes, and heating configurations. One of our core strengths is translating concepts into concrete solutions. The Boyd team works together throughout the development process to convert your designs from a concept through final production. Our process engineers will help you determine the feasibility of specific design elements, identify appropriate materials and processes, achieve performance requirements, and optimize the workflow. With our in-house roll-to-roll screen printing equipment, Boyd is ideally suited for high-volume production of PTC heaters.

Want to heat things up? Start by contacting Boyd Corporation to discuss your heating requirements such as product application, temperature requirements, etc. It is the perfect synergy between expertise, experience, and engineering that sets Boyd apart from the rest and delivers a more stable and uniform heater product. With decades of expertise and manufacturing experience, Boyd Corporation is here to deliver a seamless development process.