

# SmartHeat SLT™ Frequently Asked Questions

Learn how to incorporate this technology into your next project.

## Is SmartHeat SLT™ most similar to a resistor, capacitor, or inductor?

SmartHeat is a resistive technology. What separates this product from traditional resistive technologies is a unique positive temperature coefficient (PTC), which establishes a strong, exponential relationship between resistance and temperature. This creates a self-tuning effect that makes SmartHeat suitable for a variety of warming applications.

SmartHeat utilizes a resistive foil bus-pattern to deliver a voltage potential to the underlying heating foil. This bus-pattern may act as an inductor in certain configurations, but this is a byproduct of the design and not the intended function.

## How does SmartHeat react to common automotive and industrial fluids?

Exposure to common automotive and industrial fluids is not recommended. Short duration contact will not impact performance, however extended contact and submersion may degrade the dielectric properties of the heater. SmartHeat is constructed with a polyimide dielectric encapsulant. The rate of absorption into this outer protective material should be considered when selecting SmartHeat for applications involving fluid contact.

For fluid heating applications, it is generally recommended that SmartHeat be placed on the exterior of the fluid housing (pipe, reservoir, pump, etc.). SmartHeat's built-in safety mechanism makes it ideally suited for heating low-melting-point plastic housings. Where direct fluid contact is required, a metallic heat spreader may be applied to the areas of the heater that require fluid contact, or a hermetically sealed sleeve may be applied for direct submersion.

## Can SmartHeat devices be stacked to increase temperature or power output?

SmartHeat devices may be stacked or overlapped without impeding performance. Although it is possible to increase temperature or power output by stacking, the effect is often minimal and can be accomplished by alternative, more cost-effective means.

The real benefit in stacking SmartHeat is ease of installation. In situations where a heater must be wrapped or stitched around a unique geometry, SmartHeat automatically regulates overlapped areas to prevent an overtemp condition. Areas of overlap also have the benefit of increased bond strength and more uniform heating.

## How does SmartHeat respond to drastic changes in environmental conditions?

SmartHeat strives to maintain a constant temperature. It will produce high power when attached to a cold object, and will rapidly warm the object to its set point while never exceeding a prescribed safety temperature. As the heatsink and environment change, the heater will increase or decrease its power output to compensate.

## I understand that SmartHeat is inherently self-controlling, but is there any advantage to using a secondary, external controller with SmartHeat?

It may seem counterintuitive to add a feedback loop to a "controller-free" system, however there are situations where this is a very reasonable approach. For instance, critical applications may require two independent thermal shutoffs. While SmartHeat can suffice for the first level of safety, an additional thermal fuse or thermostat may be required as a secondary level.

Other applications may require a combination of precise set point control and built-in safety. The addition of an external sensor allows the system to be tuned to a more precise set point (especially in highly dynamic environments), while the core SmartHeat layer gives the system a built-in safety mechanism.

## Is it possible for SmartHeat to act as an On/Off controller that is only active below a specified temperature?

SmartHeat will gradually reduce its power output above the designed set point for the system. It does not have the same complete cut-off characteristic as an On/Off controller. Instead, SmartHeat should be thought of as a no-overshoot PID controlled system. SmartHeat will only draw as much power as is needed to maintain its equilibrium set point. In a warm, low-load environment, the heater will draw significantly less power than in a cold, high-load environment. It will react to changes in load by increasing or decreasing its power output to maintain equilibrium.

## Is the SmartHeat construction UL rated?

Minco's SmartHeat construction is not yet UL rated. The outer encapsulant (polyimide) is UL recognized, however the core heating layer has not been tested. This testing is on the roadmap for the product line and the results will be made available as soon as they are ready.



### **What are the storage requirements for SmartHeat technology? If heaters are stored for years, will they be operational when they are put into service?**

SmartHeat should be stored in a clean, dry environment with temperatures between -40°C to 100°C and humidity up to 95%, non-condensing. In these conditions a SmartHeat device can be expected to remain indefinitely prior to placement into service.

### **What is the durability of SmartHeat? How long of a lifecycle can be expected?**

Minco is currently collecting lifecycle data for SmartHeat. As of the writing of this FAQ, various SmartHeat constructions have been under power in a test environment for nearly 2 years with no measurable degradation to heater performance. Minco does not anticipate any issues using SmartHeat for critical, long-term applications in excess of 10+ years and will continue collecting data to confirm. It is however at the discretion of the customer to validate SmartHeat for their end use application and required longevity.

### **Can SmartHeat survive injection overmolding? What are the consequences of high temperature exposure to the product?**

This depends on the type of injection molding. Certain molding materials, including ABS, Acrylic, and Polyethylene require melt and mold temperatures in excess of SmartHeat's upper environmental limit (100°C). It is not recommended that SmartHeat be used in these processes without prior validation. Exposure to temperatures in excess of 100°C may cause a downward shift in the set point temperature and power output for SmartHeat.

Injection molding and overmolding materials that can be processed within SmartHeat's environmental limits (silicone for example) are acceptable for use with SmartHeat. It is still recommended that any special conditions (repeated cycles, long exposure, etc.) be validated prior to production release.

### **Is the SmartHeat construction durable enough to withstand repeated bending?**

Yes, SmartHeat is constructed from durable, flexible materials that can withstand static or dynamic bending. It is important that areas with dynamic bending be discussed early on, as this can affect the positioning and layout of the termination area.

### **Can SmartHeat withstand pressure application from lamination, clamping, or natural weight of the heatsink?**

SmartHeat is capable of withstanding high, uniform pressure. It is important that the pressure be well distributed across the heater's surface to prevent puncture or physical damage. Pressure lamination, mechanical clamping, and the weight of common heatsinks are readily managed by SmartHeat.

### **What is the typical thickness of a SmartHeat device?**

Minco's standard SmartHeat construction measures 0.013 inches nominal. The minimum available thickness on a custom basis is 0.011 inches nominal. Heaters that require pressure-sensitive adhesive backing, a metallic heat spreader, insulating foam, or high dielectric strength will have increased thickness and should be quoted by Minco engineering.

### **What are the size limitations for your SmartHeat product line (i.e. the biggest and smallest heater you can produce)?**

The maximum size heating element that Minco is capable of manufacturing is 7 in. x 22 in. Larger heaters can be manufactured by combining (stitching) multiple heating elements on a common polyimide substrate and cover. The maximum size stitched heater Minco is capable of manufacturing is 22 in. x 42 in.

The minimum size heating element that Minco is capable of manufacturing is 0.5 in. x 1 in. Smaller heaters can be manufactured by locating the termination area on an external tab, or by using surface mount or pin-header connections.

### **Does SmartHeat take any longer to design or build than a traditional etched-foil heater?**

No, SmartHeat is built with the same methods and equipment as a traditional etched-foil heater. Leadtimes between traditional products and SmartHeat products are comparable. In cases where the thermal load is significant or highly dynamic, multiple prototype iterations may be required to achieve the designed set point for the system. This is a normal part of the design process that can be discussed up front with Minco Engineering.

## What is the maximum power density that can be achieved with SmartHeat?

SmartHeat strives to maintain a constant temperature and will produce as much power as is necessary to maintain equilibrium. Each heater will adjust its resistance, and in turn wattage based on the heatsink, contact method, and environment temperature. Minco designs heaters for a constant temperature. It is then up to the surroundings to determine what the wattage and warm up time will be when the heater is turned on.

The maximum power density is both application and design specific. For new applications, it is recommended that customers work with catalog/standard heaters for proof of concept testing. This is the most reliable means to characterize SmartHeat's power density for a specific application.

## What is the maximum current draw that should be expected from SmartHeat during a cold start? Is there any way to limit or reduce the startup current?

Start current, similar to power density, is application and design dependent. As a rough approximation, the start current can range from 5x to 20x the steady state current. The exact value is dependent on various parameters including the design formulation, supply voltage, heater size, coverage, insulation, and environment temperature on startup.

In cases where design strategies do not fully address startup-current concerns, there are simple electrical components that can be added to the heater design. Both fixed inductors and negative temperature coefficient (NTC) thermistors can offer a cost effective way to lower the startup-current while still not adding the cost, weight, and complexity of an external control system. The addition of the thermistor significantly reduces the peak startup-current, but does slightly increase the time required to get to steady state.

## SmartHeat has a listed tolerance of $\pm 5^{\circ}\text{C}$ . Is there any way to improve this performance?

Applications with tighter tolerance requirements can be accommodated under certain conditions (low thermal loading, consistent environment, highly insulated, etc.). Tighter tolerance control can also be met by sorting and heightened inspection criteria at end of line inspection, but this is generally not recommended because it adds cost to the build and reduces overall product yield. In situations where tight control and a high degree of safety are required, consider pairing SmartHeat with an external sensor and controller.

## What is the difference between set point temperature, element temperature, and safety temperature?

Set point temperature is measured at the heatsink. It is the desired temperature that the heatsink should be warmed to. This value is generally customer driven and varies based on the application and condition of the heatsink at equilibrium.

Element temperature is measured at the internal heating element. This value is Minco driven and depends on the connection method, environmental conditions, heatsink type, and relative size of the heater to the heatsink. The element temperature will always be higher than the set point temperature due to thermal losses between the heating element and the heatsink.

Safety temperature is the upper shutoff point for a SmartHeat device. Above this temperature, the heater will produce minimal power. This built in shutoff point is integrally tied to the set point and element temperatures. SmartHeat devices are designed to prevent thermal runaways and to protect surrounding materials that are prone to thermal damage.

## What temperature set points are available for SmartHeat? Is the set point adjustable in the field?

Minco is capable of designing SmartHeat for temperature set point between  $10^{\circ}\text{C}$  and  $70^{\circ}\text{C}$ . Please consult your local sales representative for applications outside of this range, or for applications with high thermal loading (subzero climates or dense metallic heatsinks).

Set point is established during manufacturing and cannot be adjusted in the field, except through the use of a variable voltage power supply.

