NPH

Silicone Rubber and Kapton (Polyimide) Heaters-Introduction

Heating for Medical Imaging, Medical Diagnostic Instruments and Analyzers, Heating of Aerospace Instrumentation-Satellites and Spacecraft, Environmental Control of Electronics, Optical Equipment and Computers, Antennas. Silicone Rubber Heating Tapes for Freeze Protection, Viscosity Control, Laboratory Apparatus, Gas Tubing and Industrial Applications.

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Introduction to Flexible Silicone Rubber and Kapton (Polyimide) Heaters

A flexible heater is made out of a stranded wire (mostly Ni-Chrome) or an etched foil sandwiched between layers of dielectric materials. The most common dielectric materials are **Kapton**, **Silicone rubber**, Mylar and Mica.

The choice of construction (wire wound or etched foil) and thermal conductor (**Silicone Rubber or Polyimides like Kapton®)** is determined by max temperature, Watts per square inch, overall weight (example: aircraft and airspace industry) and type of **application**.

Kapton® heaters are thin film heater manufactured in edged-foil construction (similar to circuit board manufacturing); **Silicone rubber heaters** are manufactured in **edged-foil or wire-wound construction**; the decisive consideration is the max watts per square inch needed. Mica band heaters are mostly wire-wound and very commonly used in a cylindrical shape to use around tubes and such.

All **flexible heaters** can be manufactured with many different lead wire configurations and nearly an unlimited choice of **temperature sensors** can be built into them. **Flexible heaters** with Watt densities above 5 watts per square inch cannot dissipate the heat through convection in still air alone, they would burn out and therefore need to be attached to a material acting as a heat sink.

Our Engineering staff can help you to select the right configuration for your application.

Silicone Rubber Heaters

Sandwiched between layers of silicone rubber are uniformly spiraled (stranded) resistance wire web (that covers the entire surface) or an etched foil. The layers are then bonded together through heat and pressure. The wire wound design allows for up to 10 watts per square inch, while with the etched foil design up to 20 watts per square inch can be achieved. Silicone rubber heaters are used up to 400 deg F.

Applications of Silicone Rubber Heaters

This sandwiched construction makes silicone rubber heaters an ideal solution to the requirements of many low and medium temperature applications, which do not conform to the standard shapes, sizes and dimensions of band, strip, cartridge, tubular and open coil air heaters.

When silicone rubber heaters are made with a pressure sensitive adhesive backing, a thin layer of aluminum is added prior to the adhesive layer, in order to improve heat transfer and maintain its uniformity. The watt density of the heater should not be greater than 7 WSI (watts per square inch) when PSA (pressure sensitive adhesive) is used.

Silicone rubber heaters can also be vulcanized to a silicone rubber sponge for insulation.

Application examples:

1. Drum & Tank Heaters
2. Preheat molds for carbon fiber
3. Moisture protection in electronics
4. Battery and oil heating
5. security camera enclosures
6. Fuel cells, power meters, transmission
7. wafer fabrication
8. warming cabinets in food industry

We also manufacture **polyimide heaters (Kapton®)** for many different applications.

Contact NPH today to find out more about **silicone rubber heaters** and other industrial electric heating devices.

Material Choices

Silicone Rubber

The excellent dielectric properties of silicone rubber combined with the strength of fiberglass twine make silicone rubber heaters versatile and durable solutions for many applications. Wire wound elements are wound on permanent tooling to provide repeatability and pattern and have operating temperatures to 392ºF. Etched silicone has superior heat transfer, exceptionally uniform heat output, fast heat up cycle, longer life, complex circuit reproduction, and can operate to 500ºF. Hazardous-area silicone heaters are available with temperatures to 400ºF.

Resistant to: • Vibration • Separation/ Stretching • Outdoor Exposure • Most Chemicals

• Deterioration by Moisture • Ripping/ Tearing • Thermal/Mechanical shock

• Edge Loss (etched only)

Polyimide (Kapton®)

Fast warm-ups and quick responses as well as lightweight flexibility and outstanding mechanical, chemical, and electrical properties are some benefits. Their thin, lightweight design (0.005” thick) allows close thermal contact for maximum efficiency, and their distributed wattage design eliminates edge loss compensation. Kapton has double the tensile strength as fiberglass reinforced silicone, is almost 50% lighter, and meets precise heating requirements in applications with temperatures as high as 392ºF and as low as -319ºF. It is also not effected by common solvents/ fluids.

Distinct Advantages: • Dimensional stability • Tear/ Cut Resistance • High Dielectric Strength • Minimal out-gassing in high • vacuum environments • Resistance to radiation, fungus, oil and chemicals • Thinnest, Most Rugged Flexible Heater

Design Variations

Holes, Cutouts, and Notches

Your heater can be designed and fabricated in many types of configurations to fit the size and shape of your application. The holes, cutouts and notches are located per your specifications. Efficient heating element is placed within the predetermined perimeter.

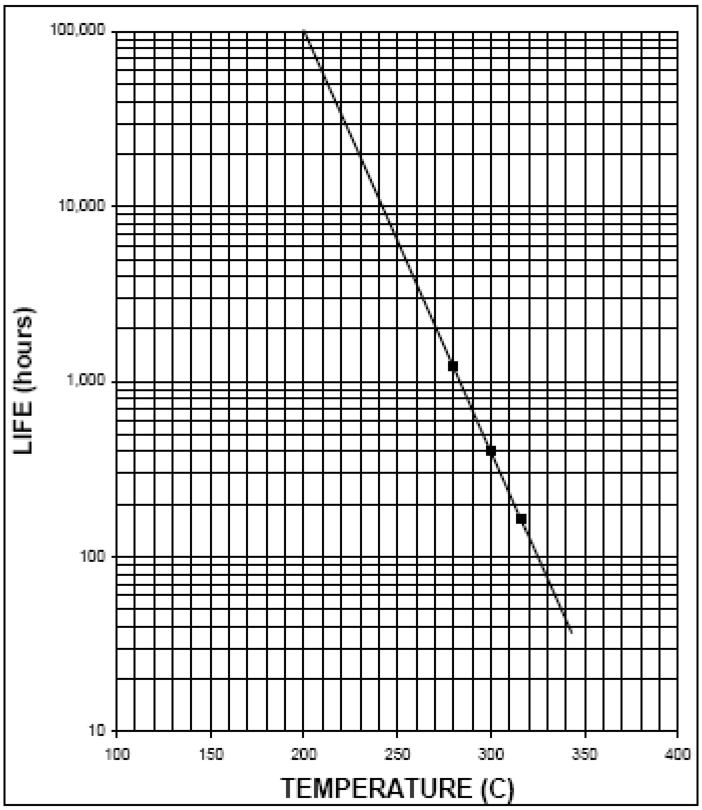
3– Dimensional Heaters

Can be designed and built to fit perfectly around the complex contours of your part. This results in efficient heating and lower heating costs because there are no areas of loss. Our designers are happy work with you to satisfy these complex design challenges.

Silicone Rubber – Service Life

Service Life of Silicone Rubber:

The service life of silicone rubber is defined by the following chart. The service life was determined when the elongation value dropped from an original value of 300% to 50%. Please bear in mind that test conditions cannot be compared to service conditions directly, but they serve as a guide to determining life expectancy.



Silicone rubber is a good selection for use in flexible heaters, as it has many unique properties. Silicone belongs to a family of synthetic polymers which are partly organic and partly inorganic. They have a quartz-like polymer structure, being made up of alternating silicon and oxygen atoms rather than the carbon-to-carbon backbone which is a characteristic of the organic polymers.

Processing: The heat-cured, or vulcanized vinyl/methyl silicone rubber is processed as gum stock, since it is a high viscosity, high molecular weight fluid polymer. Coloring agents are added to change the color from an off-white to a variety of others, the most popular being red. Red iron oxide is employed to impart the color, adding to the high temperature stability of the rubber. Resistance to fuel oil and certain greases may be improved by blending in fluorosilicone, but at a higher cost.

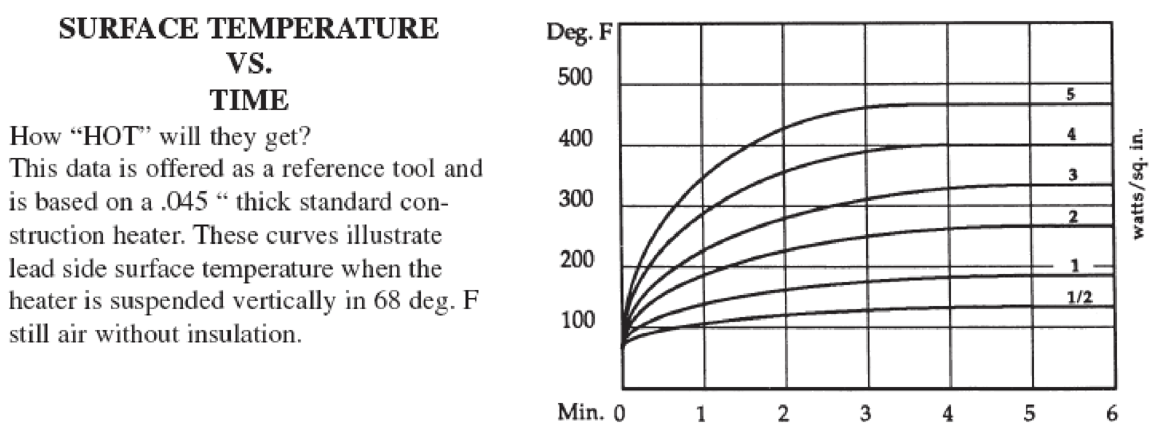
Mechanical: A typical silicone rubber would exhibit a hardness of 60 Durometer (Shore A-2), a tensile strength of 950 psi, an elongation of 300% and a compression set of 33% after 22 hours at 350 F.

Temperature Limits*:* Heaters made with silicone rubber can be expected to perform from -100 to +450 F, and the maximum short term service temperature can be extended as high as 500 F with the addition of certain heat stabilizing agents. Please consult the factory for details on additives.

Fluid Resistance*:* Silicone rubber exhibits excellent resistance to moisture, sunlight and ozone. It has good resistance to bases such as ammonium and sodium hydroxide, and excellent resistance to salts such as sodium carbonate. Acid resistance depends on the acid, but generally acetic and low concentrations of hydrochloric and nitric have little or no effect. The use of silicone rubber in phosphoric or sulfuric environments is not recommended. Motor oils, transmission fluids, and mineral oil degrade the rubber, while brake fluid and gasoline have less of an effect. Silicone exhibits good resistance to acetone, ethyl alcohol and xylene, and fair to poor resistance to benzene, carbon tetrachloride and toluene.

Moisture Resistance*:* The moisture resistance of silicone rubber heaters may be enhanced by selecting the proper configuration. Generally. fiberglass cloth is included in heater thickness selections as it dramatically improves tensile strength and tear resistance. Moisture can travel through the cross-sectional fibers of the glass, however, allowing deep penetration and reduction of electrical insulation resistance. Plies of fiberglass can be cut to less than full size, thereby interrupting the moisture path by allowing fiberglass-free silicone rubber to seal the edges. Another potential leakage path for water is the location where the lead wires are installed. Teflon covered lead wire does not bond well, even if etched, to silicone rubber. Silicone rubber lead wire should be selected, as it bonds integrally to the rubber composition of the heater element. Silicone rubber lead wire is available with a fiberglass overbraid to impart abrasion resistance, but the glass overbraid should be trimmed short where it enters the heater connection area, again removing a moisture leak path.

Silicone Rubber Heaters-Stock Heater Temperatures with Various Watt Densities



The temperatures above were obtained by placing four stock heaters horizontally on a flat surface, on a one inch high wire form. The wire form allowed heat to circulate under and over the two major surfaces.

PLEASE NOTE: Temperature controls must be used to limit the maximum operating temperature to 450F.

Applications:

SHL (2.5W/IN2) Gentle Heat	SHM (5W/IN2) Moderate Heat	SHMH (7.5W/IN2) High Heat	SHH (10W/IN2) Very High Heat
Batteries Exterior electrical equipment Medical instruments Mirror de-icing Paraffin melting Sensitive computer parts	Adhesive melters Automatic doors Book binding equipment Electric motors Food processing machines Industrial antenna	Airborne equipment Cardboard box sealing tape Ink jet printing parts Laboratory equipment Pipe and tube heating Plastic heat sealers Process flow materials	Anti-icing devices Heavy metal parts Industrial process equipment Press platens Pressure vessels Space & missle part

Use Of Silicone RTV Adhesives

(Room Temperature Vulcanized)

Silicone rubber heaters may be adhered by applying a one part room temperature curing adhesive to the underside of the part and mating it to the surface to be heated.

We recommend the following adhesives:

Dow Corning Silastic #732 (Translucent) with #1200 Primer

G.E. RTV 102 (White) with #SS4004, SS4044, or SS4179 Primer

G.E. RTV 103 (Black) with #SS4004, SS4044, or SS4179 Primer
G.E. RTV 106 (Red) with #SS4004, SS4044, or SS4179 Primer
G.E. RTV 108 (Translucent) with #SS4004, SS4044, or SS4179 Primer

G.E. RTV 109 (Aluminum) with #SS4004, SS4044, or SS4179 Primer

The adhesive is supplied in collapsible aluminum squeeze tubes, caulking cartridges, and in bulk containers. It is of a paste consistency and should be rapidly spread to a thickness of 15 to 50 mils.

Curing time is dependent on temperature, relative humidity, joint configuration, degree of confinement, sealant thickness and substrate porosity. Warm temperatures (not over 100 degrees F) and humid conditions will shorten the cure.

The heater should be firmly fixed in position and allowed to cure from 24 to 72 hours before use. Energizing the heater before a complete cure is accomplished may cause a failure of the bond line, as deep section cures require more time.

Adhesives and primers have a limited shelf life, and the containers should be marked with the last use date. Observation of shelf life is very important in obtaining proper bonds. Primer containers should not be left uncovered any longer than necessary, as the effectiveness is diminished after exposure to atmospheric moisture.

Adequate bond strength may be attained without the use of primer, but the use of it is strongly recommended.

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