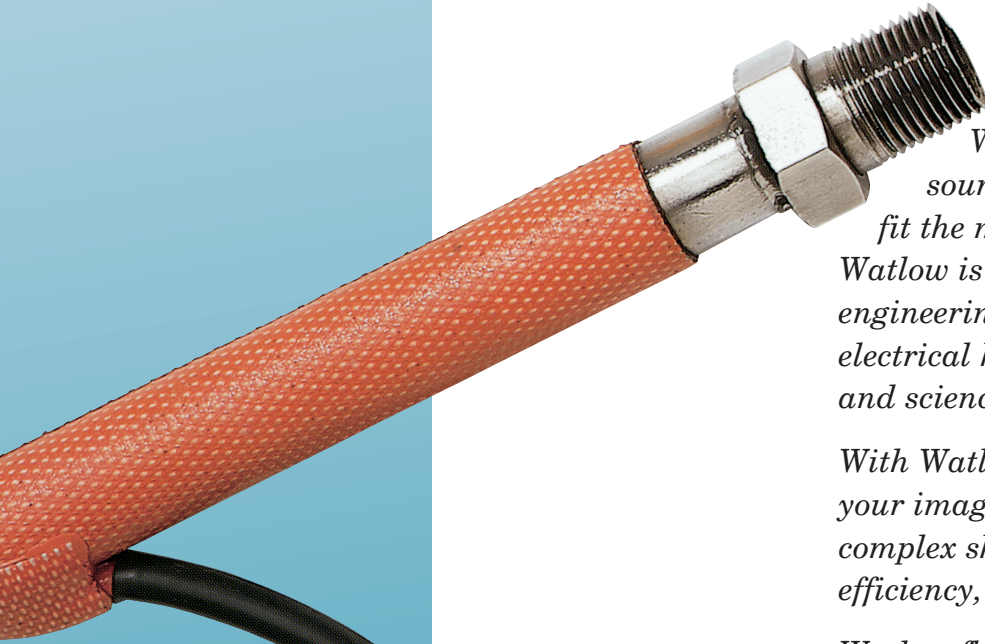


Flexible Heaters



heaters | sensors | controllers

HEATERS SHAPED TO FIT YOUR NEEDS

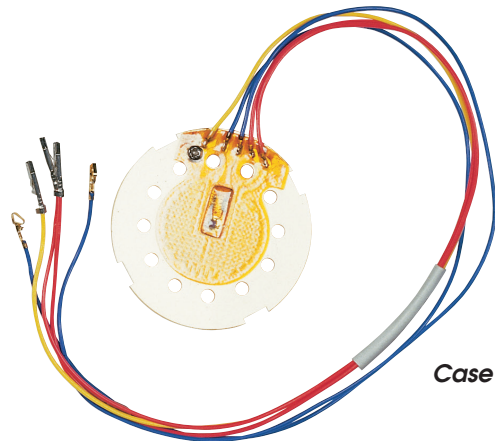


Watlow® is the world's number one source for custom created solutions to fit the most exacting heating requirements. Watlow is the recognized leader in design, engineering and production of every type of electrical heating unit for industry, business and science.

With Watlow's flexible heaters you can use your imagination to apply heat to the most complex shapes conceivable, and do it with efficiency, dependability and value.

Watlow flexible heaters have solved thousands of heating challenges as diverse as freeze protection on aircraft air sensors to dehumidifying and warming computer equipment.

Case history 51



Case history 4

HEAT WHERE YOU WANT IT

Flexible products allow you to put the heat where it is needed. Units can be designed into three-dimensional shapes and conformed to the most complex geometries. Watlow engineers literally design around the shape of your equipment, covering it like a second skin. You get the heat you need without having to make design compromises to equipment.

The flexible heater's amazingly low thermal mass and profile enables it to be used in applications that have limited space or limited weight requirements.

The heater's thin design and its direct bonding to the application results in excellent heat transfer. With the heating element as close as 0.003 in. (0.1 mm) to the heated part, you get fast heat up and cool down. This is significant for applications that have precise temperature requirements.

Even heat distribution is the result of close, uniformly spaced element paths. Standard spacing allows you to place the element to within 0.25 in. (6.4 mm) of the heater's perimeter, maximizing the available heating area. We can also design zoned wattage as required by the application.

MORE CHOICES FOR GREATER FLEXIBILITY

Watlow's flexible heater design team selects the best dielectric isolation material, element type and thermal insulation to best fit your heater to your specific application. This wide range of choices means greater flexibility in meeting your requirements.

MATERIAL CHOICES

Silicone rubber: We use this versatile insulation for temperatures up to 500°F (260°C) and watt densities from 0.5 W/in² to 80 W/in² (0.08 W/cm² to 12.4 W/cm²), dependent upon application temperature. Standard thickness is 0.055 in. (1.4 mm) using a wire-wound element and only 0.018 in. (0.5 mm) with a foil element.

Watlow applies the silicone rubber compound to a fiberglass fabric to give your heater dimensional stability while still maintaining its flexibility. The resulting unit is moisture and chemical resistant, and can hold UL®, CE, cUR® and VDE recognition. Watlow was the first silicone rubber heater manufacturer to obtain comprehensive UL® component recognition.

Polyimide: This thin, lightweight organic polymer film provides excellent tensile strength, tear resistance and dimensional stability. It can also operate in ambient temperatures as low as -319°F (-195°C). Polyimide is ideal for applications requiring low

out gassing in a vacuum, or resistance to radiation, fungus and chemicals. The material also provides resistance to solvents.

Ultra thin at only 0.007 in. (0.2 mm) when used with an etched foil element, the standard construction can be used in applications reaching 392°F (200°C) and additional constructions are available that can be used up to 482°F (250°C).

ATTACHMENT CHOICES

Watlow offers various attachment techniques, all designed for fast installation: field bonding, detachable fasteners or complete subassemblies.

Our special factory vulcanizing technique delivers excellent heat transfer through a very strong, void-free bond that ensures the best possible heater performance.



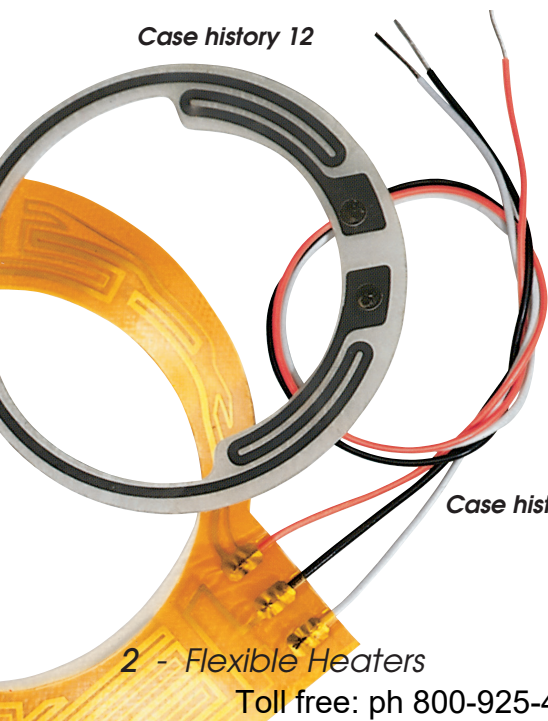
Case history 5

WHEN YOU WANT TO TURN ON THE HEAT, TURN TO WATLOW

As a complete thermal system supplier, Watlow provides the engineering experience and product leadership necessary to develop precise heating solutions. Watlow can design, recommend and build a solution to fit your exact needs.

Following are 70 case histories that illustrate the versatility of Watlow's flexible heater solutions and our engineering expertise to solve challenging problems across various industries and applications.

Case history 12



Case history 14

ALTERNATE MATERIALS

- 1.** FREEFLEX® heaters use PTFE tubing with special fittings to supply materials pre-heated to exact temperatures for rapid prototyping or stereo lithography equipment.
- 2.** A polyimide heater with an etched foil element pre-warms blood before it is introduced to a surgery patient.
- 3.** A silicone rubber heater with special flame-retardant properties is used to warm batteries in communications applications.
- 4.** A complete assembly, including a polyimide heater and sensor is bonded to a customer supplied plate for use in a kidney dialysis machine.
- 5.** A polyimide heater with an etched foil element is used by a window manufacturer to demonstrate the energy efficiency of his product. This thin, transparent heater provides uniform heat as it lies between two window panes of a demonstration unit.
- 6.** A low temperature polyimide heater is needed for a vacuum vapor deposition process during semiconductor manufacturing to ensure uniform and accurate vapor etching. The etched foil heater element, is designed with distributed wattage and internal thermocouples. The unit is bonded to the customer's part with a shielded foil cover.
- 7.** Silicone rubber heaters are factory bonded to custom foodservice trays for restaurants. Factory bonding allows higher watt densities and efficient heat transfer to the tray in a compact design.
- 8.** A small, quarter-sized polyimide heater is used to heat a critical mirror on one of the U.S. space satellites.
- 9.** Large silicone rubber heaters are used in the defense industry to heat up replacement parts installed on fighter jets.
- 10.** A silicone rubber heater is used at a remote telephone switching station to maintain battery temperature in case emergency power is required. The heater, placed under the battery, provides precise power density to keep the battery at its peak output capacity without the need for a thermostat.

11. *Silicone rubber heaters operating at correct temperatures enable expensive semiconductor processing equipment to operate at peak performance. Watlow replaced a bimetal thermostat with an integrated sensor and in-line SERIES EHG® controller. The SERIES EHG is a low-cost electronic controller with significant performance advantages over bimetal thermostats.*

12. *A thin polyimide heater eliminates moisture formation on the lens of a surveillance video camera. Applying the heater to the lens allows the camera to perform effectively even in high humidity environments.*

13. *Silicone rubber heaters are used to maintain consistent temperature for residual gas analysis. Uniform temperature of the sample from the source to the sensor eliminates a source of variance and results in improved sensitivity to the device. Zoned wattage heaters snap on the tubing enabling uniform temperature of the stainless steel elements from source to sensor.*



14. *A polyimide heater is used to heat the outside of a specialized camera lens. Special zoning of the circuit allows the customer to receive heat precisely where it is needed.*



Case history 15

ODD GEOMETRIES

15. *A silicone rubber heater with insulation and jacket can be easily removed from a hard-to-fit valve. This foam-in-place technology enables heating of complex geometric shapes.*

16. *Wire-wound silicone rubber heaters, designed in multiple trapezoidal and triangular shapes and sizes, are bonded with adhesive to the back side of a parabolic dish antenna to melt ice and snow. The heaters are activated by thermostats and dew point sensors.*

17. *Silicone rubber heaters provide fast curing and consistent shape retention in the manufacturing of complex, hourglass shapes for musical instruments. The heaters are bonded to the metal molds over which wood is shaped for guitars and violins.*

18. *A low voltage, low wattage silicone rubber heater prevents a school bus stop sign gearbox from freezing in cold weather. The heater is bonded to the gearbox with pressure sensitive adhesive and provides the necessary freeze protection to allow the sign to swing out from the side of the bus. Holes in the heater accommodate an electric drive motor and a micro-switch.*



Case history 17

19. *Silicone rubber heaters are installed in a warming device which resembles a waffle iron to warm frozen blood prior to transfusion. Top and bottom plates are individually monitored by thermistors connected to a two-channel digital control and located at holes through the heaters.*

20. *A formed wire-wound silicone rubber heater accelerates the cure time required for epoxy sealing of spliced communication cables. The heater's cylindrical shape allows for epoxy injection parts.*

21. *A silicone rubber heater is spiral-wrapped around the flex hose in a breathalyzer for intoxication analysis, to prevent the breath sample from condensing on the inside wall of the hose.*

22. *A silicone rubber heater warms a water bottle to body temperature in a cool air humidifier for respiratory therapy.*

23. *A low watt density silicone rubber heater warms thermal-sensitive paper for law enforcement agencies. The paper is placed on a heated plate for finger-printing.*

24. *A pre-formed, custom-shaped silicone rubber heater is used by the dairy industry during cold temperatures to prevent the sampling valve on the customer's milk truck from freezing closed when testing the bacterial count of collected milk. The heater includes an insulated jacket with hook and loop straps for easy removal during daily valve cleaning. Unique features also include a thermostat to control critical upper and lower temperature ranges.*

25. *Flexible heaters keep a satellite dish antenna's wave guide lens clear of snow and ice. The heater, shaped like a dog collar, utilizes a wire-wound element. Heater materials are weatherproof and include a built-in freeze protection thermostat and a power cord that meets military specifications.*



Case history 20



Case history 34

26. A dome-shaped silicone rubber heater provides a controlled cure for epoxy which surrounds a complex and sensitive electronic package used in the nose cone of airplanes.

27. A one-sided, "naked" silicone rubber heater is formed around five sides of a quartz holding tank to maintain acid etchant temperature during silicon wafer processing.

28. A wire-wound silicone rubber heater is intertwined between the cells of a nickel cadmium battery. Pre-formed ends provide easy installation by "locking" around the first cell.

29. Silicone rubber heaters with etched foil elements prevent ice crystal formation in an airport's highly sensitive runway day/night visibility sensors.

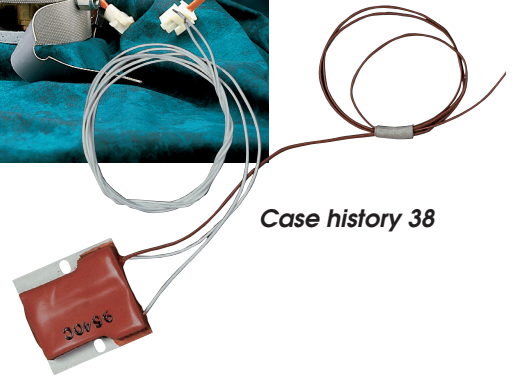
30. A pre-formed, cylindrical-shaped, etched foil silicone rubber heater provides heat to activate heat-shrink sleeving placed over a splice in a fiber optic cable.



31. Silicone rubber heaters are used to bond film to blank printed circuit boards prior to exposure and etching. The heaters are factory vulcanized to the inside of the laminating rollers, providing uniform heat and consistent bonds.

32. Pre-formed silicone rubber heaters act as portable ovens around plastic pipe joints. The heaters use integral bimetal thermostats to maintain proper epoxy cure temperature.

33. A silicone rubber heater is spiral-wrapped around a hose leading to a hot melt glue nozzle to prevent glue from solidifying.

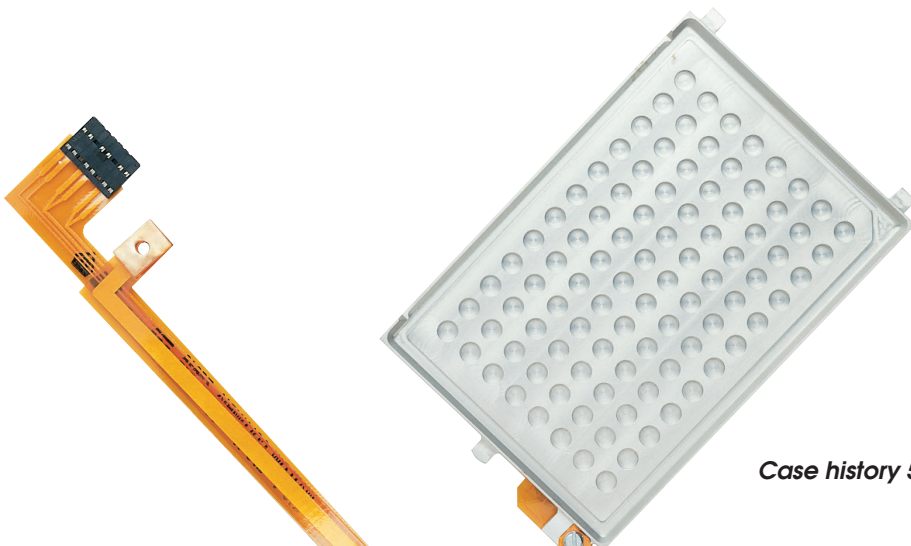


Case history 38

BONDED SUB ASSEMBLIES

34. An etched foil silicone rubber heater is vulcanized to a precisely machined and plated tube used on a respiratory therapy device. The machining allows component parts to snap onto the ends of the tube. This subassembly can then be easily mounted into the respiratory device.

35. A medical device needs to heat blood for use in an operating room. Precise control of a high watt density heater requires the heaters to be factory bonded to yield extremely even heat distribution.



Case history 50

36. Attaching a heater to a convex plate presented a challenging problem for a commercial photo processing equipment manufacturer. Factory bonding proved to be the cost effective way to improve performance.

37. Proper and adequate tooling enables Watlow to factory bond to the inside diameter of stainless steel tubes.

38. An etched foil silicone rubber heater is bonded to an anodized plate for heating test tubes in laboratory equipment. Before the heater is molded, two sensors are included to complete the assembly.

39. A silicone rubber heater is factory vulcanized to the outside of a tube leading to the grease filter in a restaurant's deep fat fryer, maintaining the grease in a flowable state.

40. Tractor trailer air brake lines use compressed ambient air containing moisture. This can cause freezing problems in cold climates and block the lines. A 2 in. (51 mm) diameter, donut-shaped silicone rubber heater is factory vulcanized to the feed valve on the air reservoir tank. This prevents air valve freeze-ups in temperatures as low as -70°F (-57°C).

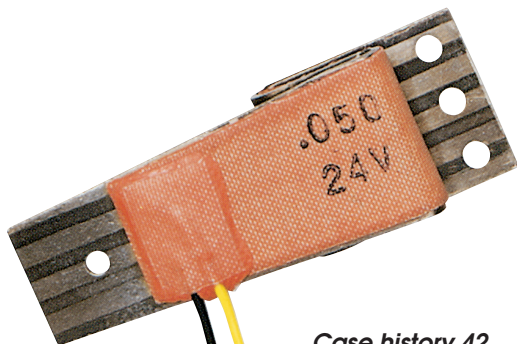
41. A silicone rubber enclosure heater provides freeze protection for outdoor automatic teller machines (ATM). The heater is factory vulcanized to a metal bracket with an integral thermostat to maintain the ATM's internal air temperature above freezing. The unit also acts as a dehumidifier in summer months.

42. The fire link is the mechanical actuator portion of a fire control system that operates sprinkler system valves, fire doors and dampers. For testing purposes, a very thin, etched foil silicone rubber heater, in either 24 or 120 volts, is vulcanized to the reusable bimetal fire link. The heater, controlled individually from the fire control panel, simulates an actual fire.

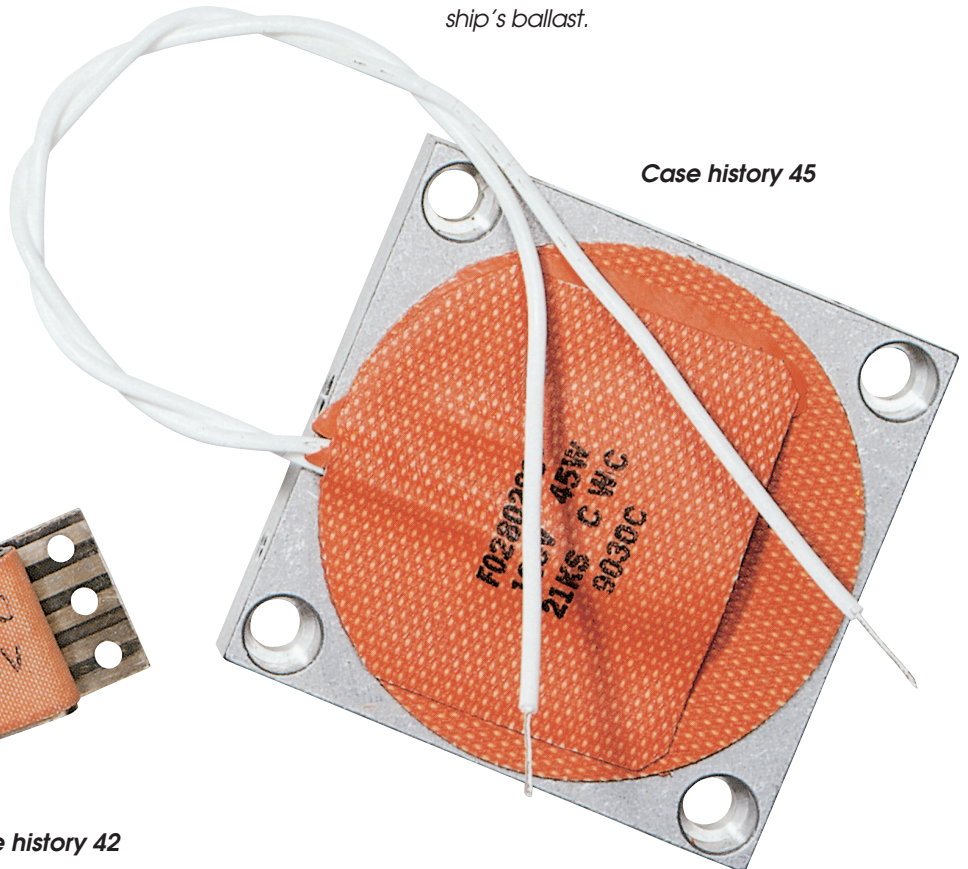
The etched foil circuit is used because of the high watt density, 55 watts in a 2½ square inch area, required in this application. It is vulcanized to the part due to the unusual shape of the link.

43. An etched foil silicone rubber heater is bonded to the developer tray in an automatic dental x-ray developing machine. The heater includes an integral thermocouple to maintain proper temperature.

44. Heat is required in an underwater application to activate a shape memory alloy. A high wattage, etched foil unit is factory bonded to the alloy sleeve with a custom silicone insulation jacket molded around the assembly to provide a watertight package. When heat is applied, the alloy sleeve expands with sufficient force to shear a bolt and release the ship's ballast.



Case history 42



Case history 45

45. An etched foil silicone rubber heater assembly was developed for a medical equipment manufacturer as a reliable and accurate method for maintaining body temperature of blood samples. Heaters are factory vulcanized to aluminum blocks which sandwich a precision hypo tube.

46. A silicone rubber heater, factory vulcanized in a spiral wrap around the connecting pipes of a fast food fryer, keeps cooking oil in a liquid state.

47. A silicone rubber heater is adhesive bonded to an aluminum casting of a blood analyzer sampler block that holds vials of blood samples.

48. A silicone rubber heater is vulcanized to an aluminum cup that warms reagents used in blood clot sensing and recording instruments.

49. Silicone rubber heaters keep medical gauze dry during production. The heaters are factory vulcanized inside metal rollers which the gauze passes over.

INTEGRAL SENSING AND CONTROL DEVICES

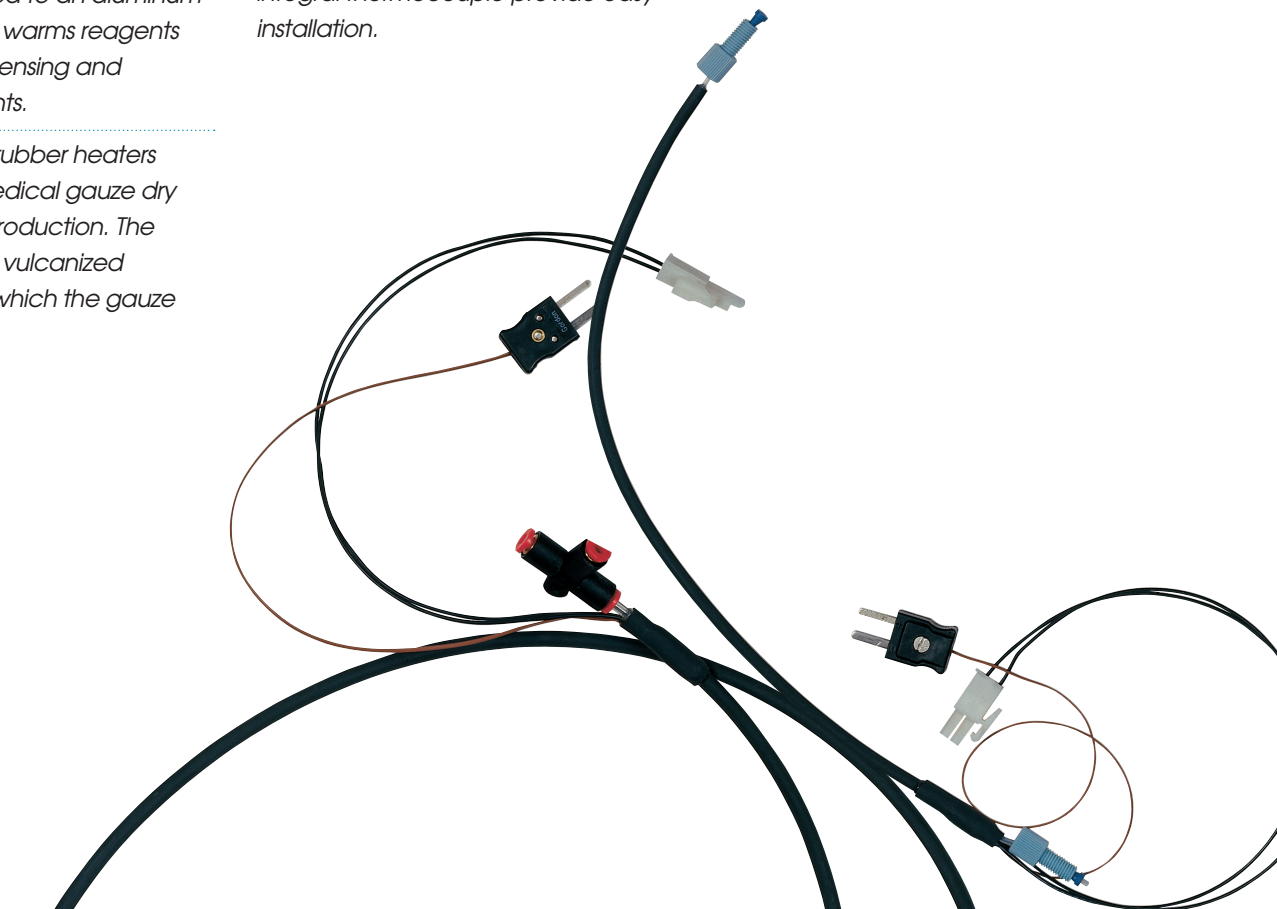
50. A silicone rubber heater with a polyimide flexible lead is used in DNA test equipment. This application requires an ultra-thin flexible power lead that also incorporates the sensor leads with the power leads. Polyimide was the perfect choice. By combining materials, Watlow was able to transition the temperature signal from the internal RTD out through the polyimide flexible lead to a single connector, making the subassembly very easy to install.

51. A wire-wound silicone rubber heater is bonded to a tube to prevent moisture condensation. A cord set and integral thermocouple provide easy installation.

52. A silicone rubber heater provides freeze protection on a pneumatic valve that controls the rudder function for a small private plane. The heater, with an integral fiberglass insulation jacket, is wrapped around the valve with hook and loop closures. Fail safe protection is achieved with redundant elements and thermostats glued directly to the valve.

53. A silicone rubber heater includes a 150°F (65°C) over-temperature protection thermostat in a bonding application for fiberglass reinforced plastic pipe. The 5 in. (12.7 cm) wide wire-wound heater is installed on a 42 in. (107 cm) diameter pipe with quick disconnect spring fasteners.

Case history 69



54. Wire-wound silicone rubber heaters with remote-mounted air sensing thermostats are used by a manufacturer of meters which monitor the flow of dry materials such as grains and powders. The control box, which contains the equipment's electronic components must be protected from damaging moisture that forms during freezing weather. The heating systems are UL® and C-UL® component recognized as required by the customer.

55. A wire-wound silicone rubber heater pad with backside insulation was developed to heat-shrink sleeving around telephone cables. A thermostat and thermofuse provide overtemperature protection.

56. Silicone rubber heaters, with built in thermocouples, control temperatures in composite bonding repair of military and commercial aircraft.

57. A cable epoxy-seal splice requires a portable heat source when making outdoor mobile field repairs. A portable, wraparound silicone rubber heater, with integral bimetal thermostat and overtemperature protection thermal fuse, compensates for low ambient temperature.

58. A silicone rubber heater, with an integral bimetal thermostat, heats a water pan used to keep cheese warm in restaurant dispensers.

59. A silicone rubber heater attached under a restaurant's counter pre-warms cans of hot fudge and other sundae toppings. An integral bimetal thermostat holds the cans at 120°F (49°C).

60. Silicone rubber heaters with integral thermostats maintain the walls of a silicon wafer washer/dryer at 160°F (71°C) to expel all water residue during the drying cycle.

61. A detachable, wire-wound silicone rubber heater, with a thermostat control and high limit thermal fuse, provides a protected and reliable heat source to extract Freon® gas from a 20-pound tank.

62. Watlow applies the SERIES EHG SL10 temperature controller in the power cord of the silicone rubber heater for semiconductor gas delivery lines. These lines must be held at precise temperatures to maintain the correct chemistry. In addition, the safety requirements call for UL® recognized overtemperature protection.



Case histories 62 and 63

By utilizing the new SERIES SL10 the gas line temperature is accurately controlled. Moreover, should an overtemperature condition arise,



Watlow Silicone Rubber Heaters Help Launch Patriot Missiles

The Patriot missile, which gained fame for its success in the Persian Gulf, must be protected from frost and moisture in order to function properly. When the missile was first built, a subcontractor for the U.S. government approached Watlow for ideas on how to prevent malfunction due to weather conditions.

Watlow recommended its silicone rubber heaters because they are lightweight, resistant to harsh conditions such as freezing temperatures and moisture, and can be made in virtually any shape or size required.

The subcontractor asked Watlow to build the heaters in 4.6 meters (15 ft.) long strips, to be mounted on the launch rails. Later, the customer requested Watlow to provide not only the heaters, but also the subassemblies. This involved bonding the heaters to the metal launching rails.

As the Gulf War gained momentum, Watlow increased production of the heaters substantially. After the war ended, a branch of the U.S. Defense Department recognized Watlow for "an exceptional job" in providing quality products in a timely fashion.

the system can be re-set by simply cycling power. The SERIES EHG SL10 allows for a significant increase in up-time on critical equipment.

63. Silicone rubber heaters wrapped around grease holding tanks kept them warm to allow cooking grease to flow when needed. These tank heaters are held at the proper temperature by using a Watlow SERIES EHG temperature controller. The SERIES EHG and thermocouple sensor are factory wired into the heater power cord and pre-programmed to the exact application temperature requirements. The SERIES EHG has greater accuracy and longer life than the bimetal thermostats that were typically used.

MISCELLANEOUS

64. A silicone rubber heater provides freeze protection for an automatic surface observation system that feeds weather information to airports.

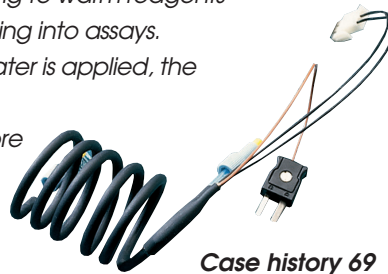
65. Silicone rubber heaters, with etched foil elements, are installed under stainless steel food warming tables at fast food restaurants. The heaters maintain water at 140°F (60°C) in a steamer cabinet to keep hamburgers warm and moist until they are served.

66. Silicone rubber heaters act as dehumidifiers in coffee vending machines to keep powdered sugar and coffee creamer dry for free flow.

67. A silicone rubber heater is attached to a motor oil reservoir tank in a performance car, minimizing engine wear and reducing friction start-up.

68. Silicone rubber heaters are adhesive bonded to the hydraulic oil reservoir on a parking lot gate to maintain lubricant viscosity.

69. FREEFLEX heaters are used to heat small diameter PTFE tubing to warm reagents prior to dispensing into assays. Although a heater is applied, the tubing remains flexible, therefore minimizing the space required in the lab.



70. Silicone rubber heaters are used on the tires of drag race vehicles requiring pre-heating to improve traction. The heaters are wrapped around the tires and secured with latch fasteners for fast and easy removal prior to the race.

Whether the application requires silicone rubber or polyimide Watlow has the answer to apply heat precisely where it is needed.

Let Watlow be your heat solutions resource.

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Applications

Semiconductor

- Chucks
- Gas lines
- Pump lines
- Valves
- Chamber walls

Medical and analytical

- Blood and urine diagnostics
- Disease diagnostics
- Laboratory equipment
- Respiratory care and diagnostics
- Hemodialysis
- Drug delivery
- Patient warming

Foodservice equipment

- Coffee makers
- Fryer grease traps
- Warming tables
- Food holding equipment

Satellite/Communications

- Aerospace
- Relay stations for communications
- Satellite stations
- Satellite deployment

Electronics/Telecommunication

- Enclosures
- Batteries
- Antenna

Industrial equipment

- Compressors
- Epoxy curing equipment
- Gensets
- Photo processing