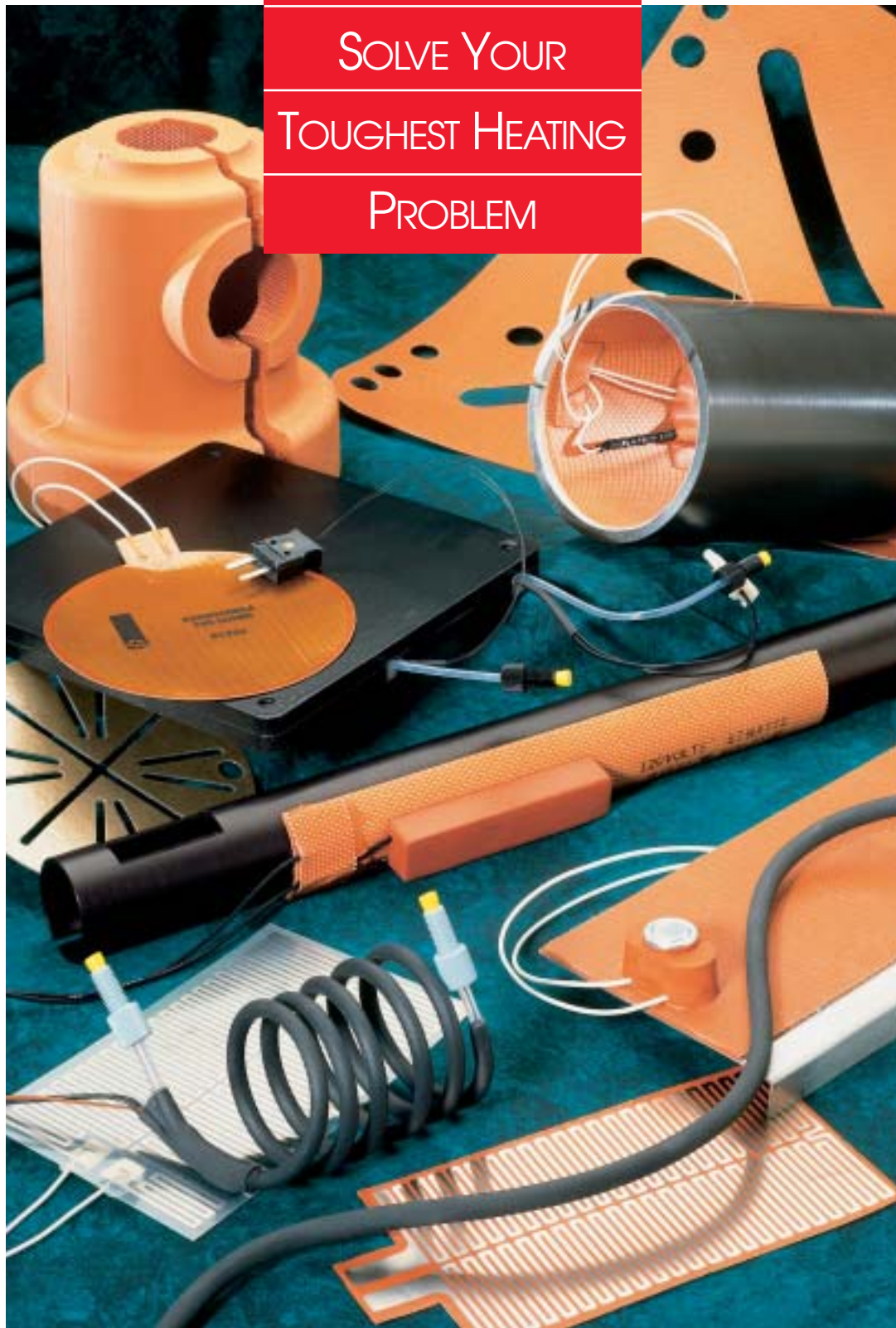
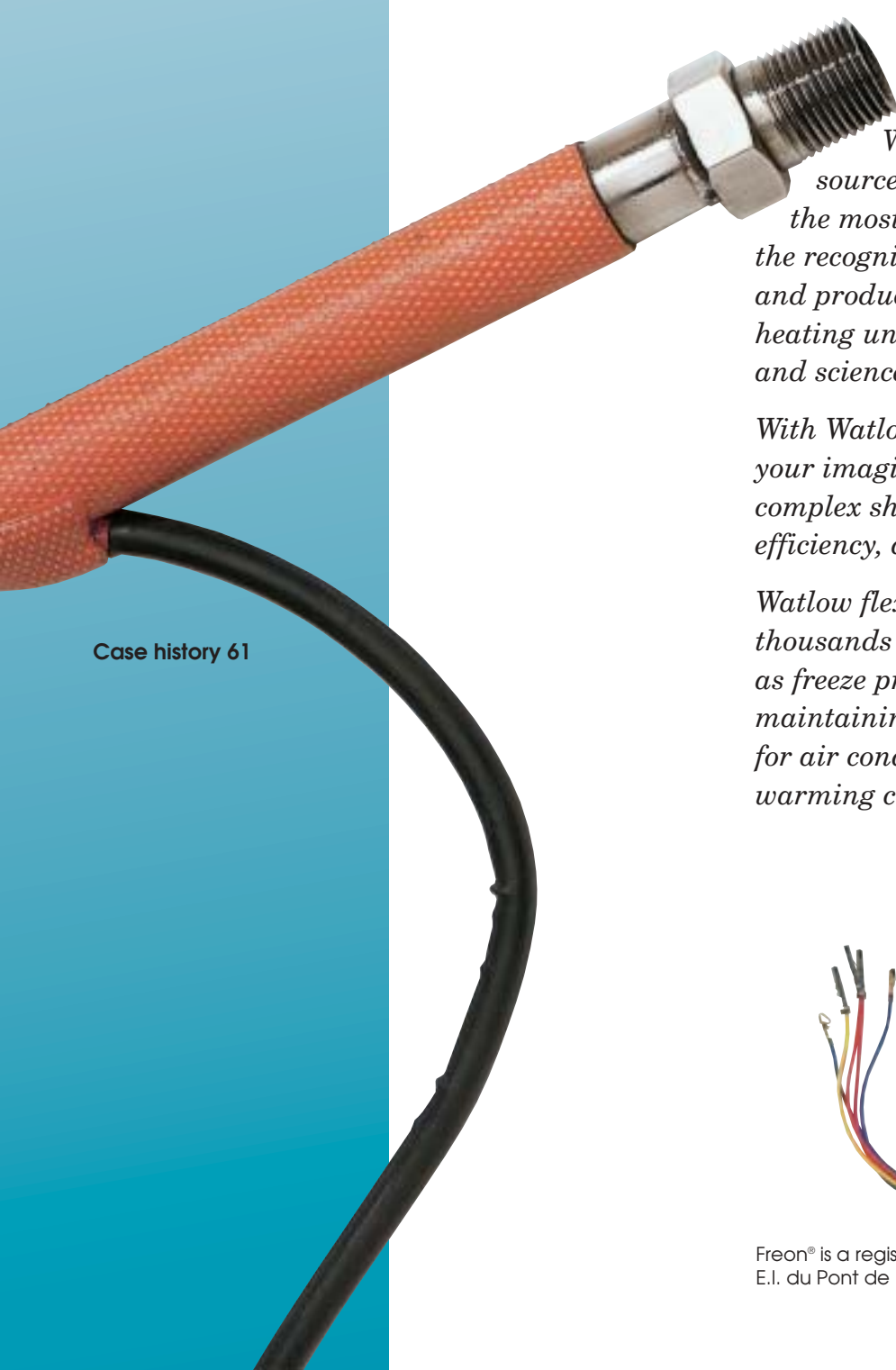


FLEXIBLE HEATERS

NEW WAYS TO
SOLVE YOUR
TOUGHEST HEATING
PROBLEM



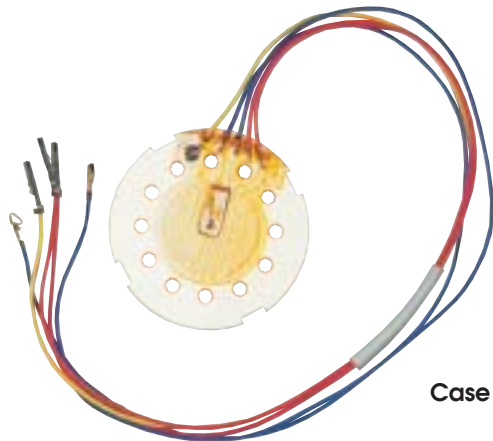
HEATERS SHAPED TO FIT YOUR NEEDS



Watlow is the world's number one source of custom created solutions for the most exacting heating requirements... 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 maintaining pressure on Freon® reservoirs for air conditioning to dehumidifying and warming computer equipment.



Case history 4

Freon® is a registered trademark of
E.I. du Pont de Nemours & Company.

Case history 61

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 the heater to be used in applications that have limited space or limited weight requirements.

Excellent heat transfer results from the heater's thin design and its direct bonding to the application. With the heating element as close as 0.003 inch away from the heated part, you get fast heat up and cool down in response to controls. 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 one quarter inch 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 from five insulating materials and two element types when fitting 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 260°C (500°F) and watt densities from $\frac{1}{2}$ W/in² to 80 W/in² (dependent upon application temperature). Standard thickness is 0.055 inch using a wire-wound element and only 0.018 inch with a foil element.

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

Neoprene: This material is very resistant to weathering, abrasion and chemicals, and is available for operating requirements of up to 120°C (250°F) in watt densities up to 5 W/in² on bonded applications. Neoprene flexible heaters have a standard thickness of 0.040 inch when used with a wire-wound element.

Polyimide (Kapton®): This thin, lightweight organic polymer film, manufactured by DuPont, gives you excellent tensile strength, tear resistance and dimensional stability. It can also operate in ambient temperatures as low as -195°C (-319°F). Polyimide (Kapton®) 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.

UL® is a registered trademark of Underwriter's Laboratories, Inc.

Kapton® and Mylar® are registered trademarks of E.I. du Pont de Nemours & Company.

Ultra thin at only 0.007 inch when used with an etched foil element, this material can be used in applications reaching 200°C (392°F).

Mylar®: This clear polymer from DuPont permits visual observation of the heating process and offers excellent dielectric strength and resistance to chemicals and moisture. The material works well with operating temperatures up to 105°C (225°F).

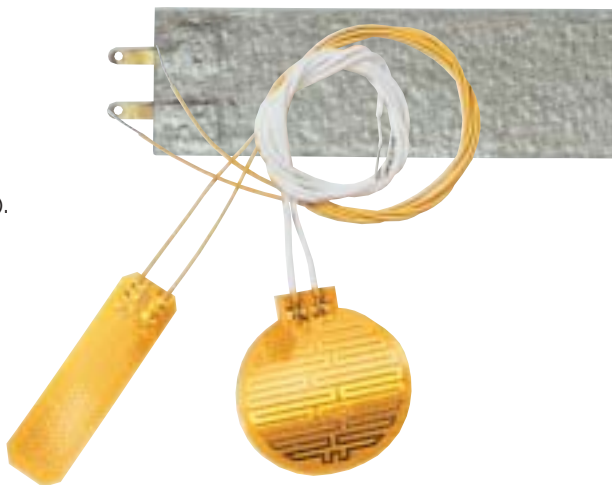
HT foil: This mica-insulated, high temperature foil is a semi-rigid heater used for clamping between two rigid parts. Operating temperatures up to 595°C (1100°F) can be achieved. Standard thickness is 0.030 inch.

ATTACHMENT CHOICES

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

Our special factory vulcanizing technique provides you with the best possible heater performance. The result is a very strong, void-free bond for excellent heat transfer.

Case history 7



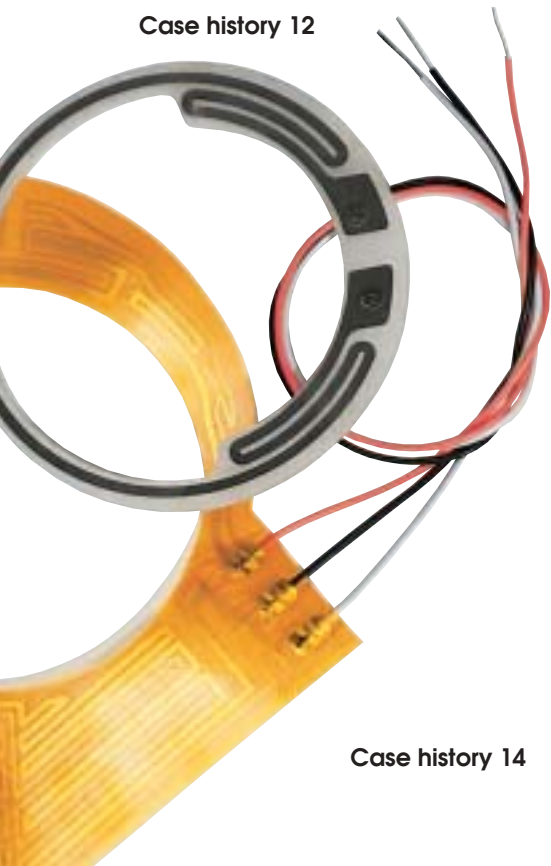
Case history 5

WHEN YOU WANT TO TURN ON THE HEAT TURN TO WATLOW

We'll provide you the engineering capability, experience and leadership necessary in developing the precise heating solutions you require.

For thought starters, here are 70 case histories to give you a better idea of just how versatile Watlow flexible heaters can be and the problems they can solve.

Case history 12



Case history 14

ALTERNATE MATERIALS

1. Neoprene rubber heaters for the aerospace industry include a copper grounding grid to prevent electrical hazards in the event that the heater is punctured.
2. A Mylar® 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 Polyimide (Kapton®) heater is bonded to a customer supplied plate to be used in a kidney dialysis machine. A sensor is included to complete the assembly.
5. A Polyimide (Kapton®) 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 (Kapton®) heater is needed for a vacuum vapor deposition process during semiconductor manufacturing, insuring uniform and accurate vapor etching. The heater, with an etched foil element, is designed with distributed wattage and internal thermocouples. The unit is bonded to the customer's part with a shielded foil cover.
7. High temperature (HT) foil heaters meet military specifications for testing silicone chips under thermal load. HT foil heaters provide uniform heat patterns and fast heat up response.
8. A high temperature (HT) foil heater is used to heat a liquid solvent tank for silicon wafer cleaning.
9. A high temperature (HT) foil heater is needed in the silicon wafer cleaning process to remove oxide deposits.
10. A neoprene 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. A neoprene heater, suitable for withstanding developer chemicals, heats a carousel of chemical tanks in a self-serve photo booth.

12. A thin Mylar® heater eliminates moisture formation on the lens of a surveillance video camera. The heater, applied to the lens, allows the camera to work properly even in high humidity.

13. A high temperature (HT) foil heater is used to heat a silicon wafer on a hot chuck for vacuum vapor deposition at 300°C (595°F) to 500°C (955°F).

14. A Polyimide (Kapton®) 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.



ODD GEOMETRIES

15. A silicone rubber heater with insulation and jacket provides an easy removable attachment to 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 adhesive bonded to the back of a parabolic dish antenna to melt ice and snow. The heaters are activated by thermostats and dew point sensors.



Case history 15

17. Silicone rubber heaters provide faster 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 school bus stop sign gearbox freezes in cold weather. A low voltage, low wattage silicone rubber heater, bonded to the gearbox with pressure sensitive adhesive, 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. Frozen blood requires warming prior to transfusion. Silicone rubber heaters are installed in a warming device which resembles a waffle iron. 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. This keeps the breath sample from condensing on the inside wall of the hose.

22. A silicone rubber heater warms a bottle of water 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. The dairy industry requires remote testing for bacterial count of collected milk. However, in the winter season, the sampling valve on the customer's milk truck freezes closed. A pre-formed, custom-shaped silicone rubber heater includes an insulated jacket with Velcro® 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 have 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 is used to provide 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.

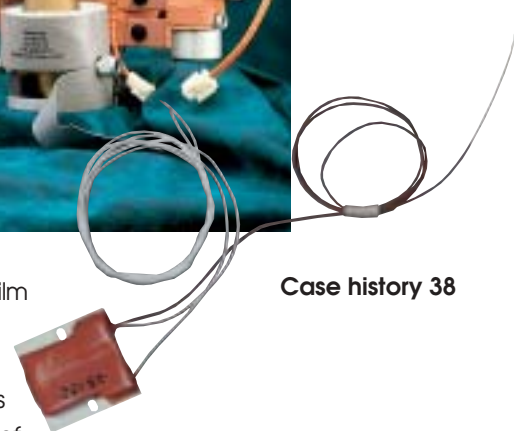
30. A pre-formed, cylindrical-shaped, etched foil silicone rubber heater provides heat to activate heat-shrink sleeving placed over a splice in a fiber optic cable.



31. Heat is required to bond film to blank printed circuit boards prior to exposure and etching. Silicone rubber 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 keep the glue from solidifying.

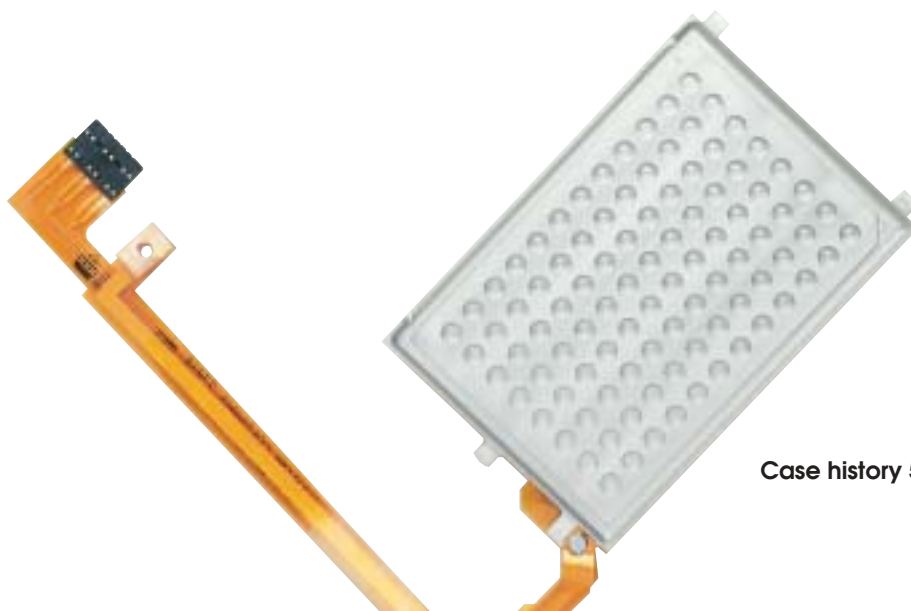


Case history 38

BONDED SUB-ASSEMBLIES

34. A wire-wound silicone rubber heater is vulcanized to a special anodized tube used in a blood analysis device. The machining allows component parts to snap onto the ends of the tube. This subassembly can then be easily mounted into the customer's equipment.

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 serious 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 Watflow 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 two-inch 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 -57°C (-70°F).

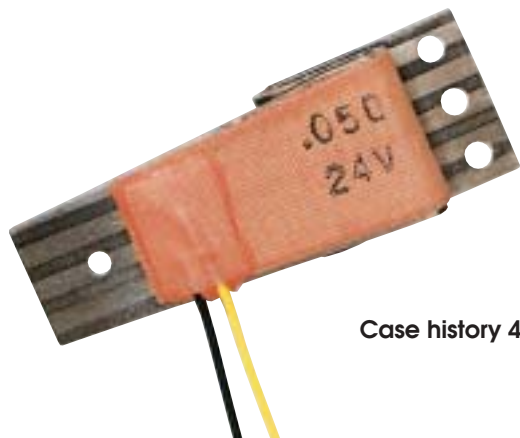
41. A silicone rubber enclosure heater provides freeze protection for outdoor automatic teller machines (ATM). The heater is factory vulcanized to a metal bracket with an integral thermostat to maintain the ATM's internal air temperature above freezing. At the same time, the unit acts as a dehumidifier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

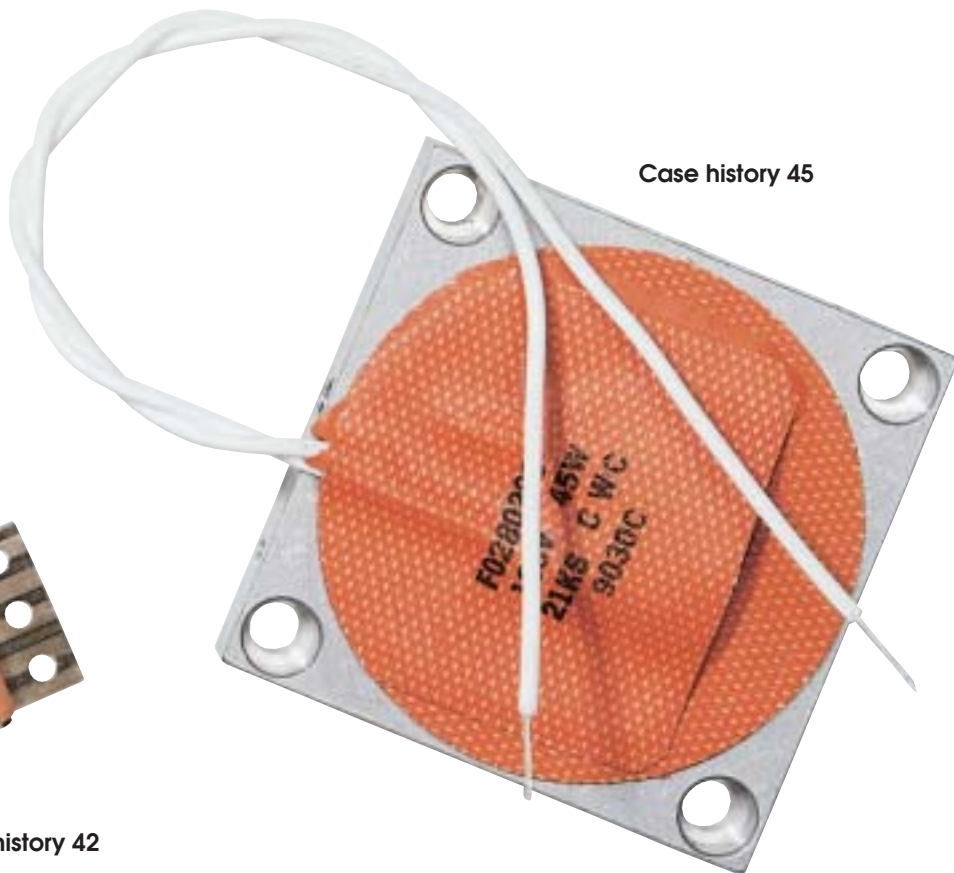
The etched foil circuit is used because of the high watt density, 55 watts in a 2½ square inch area, required in this application. It is vulcanized to the part due to the unusual shape of the link.

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. This provides 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 of 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 which warms reagents used in blood clot sensing and recording instruments.

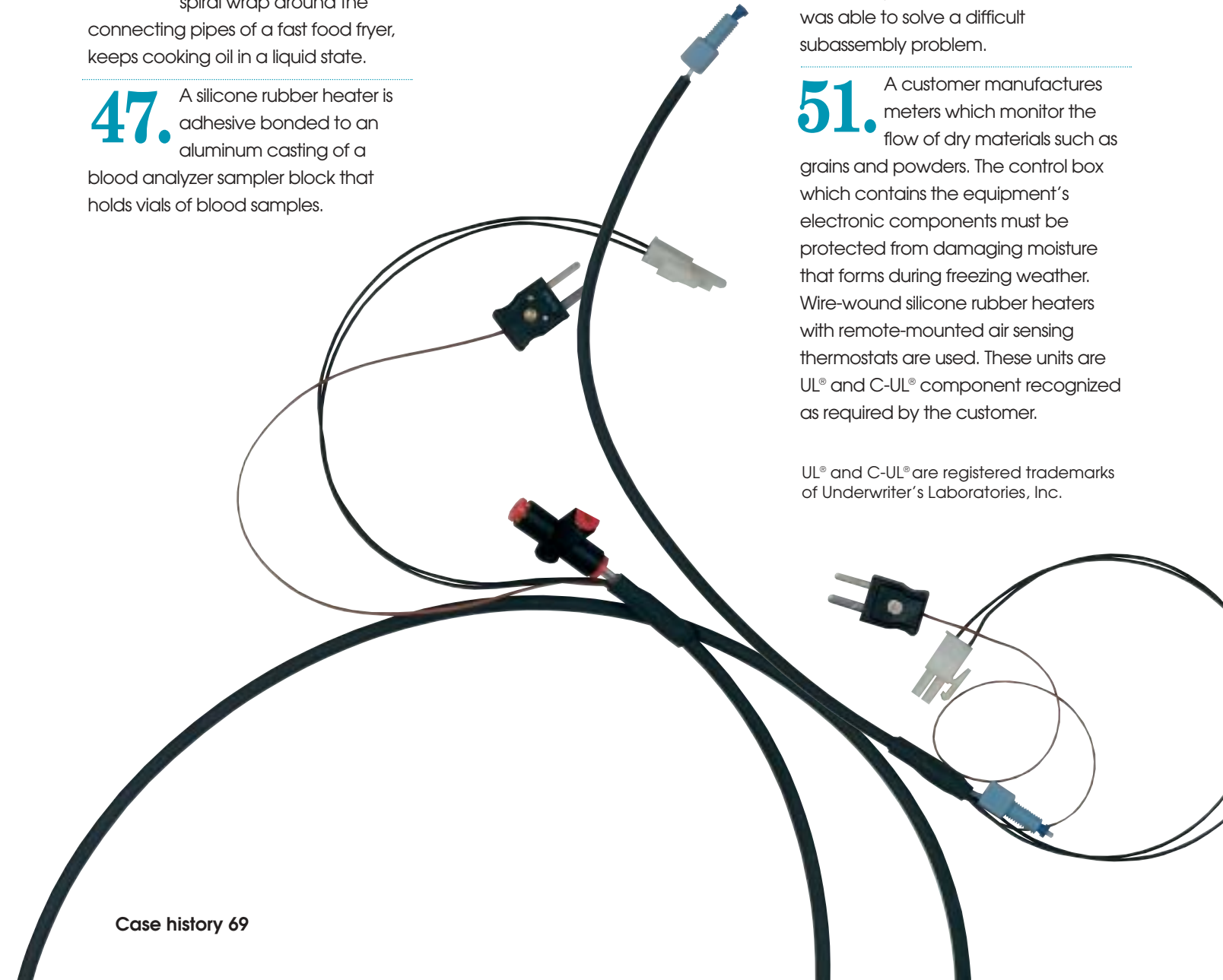
49. Silicone rubber heaters keep medical gauze dry during production. The heaters are factory vulcanized inside metal rollers which the gauze passes over.

INTEGRAL SENSING DEVICES

50. A silicone rubber heater with a Polyimide (Kapton®) 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 (Kapton®) was the perfect choice. By combining dissimilar materials, Watlow was able to solve a difficult subassembly problem.

51. A customer manufactures 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. Wire-wound silicone rubber heaters with remote-mounted air sensing thermostats are used. These units are UL® and C-UL® component recognized as required by the customer.

UL® and C-UL® are registered trademarks of Underwriter's Laboratories, Inc.



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

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

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

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

56. 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 over-temperature protection thermal fuse, compensates for low ambient temperature.

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

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

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

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

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



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.

MISCELLANEOUS

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

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

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

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

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

67. A 36-inch by 120-inch silicone rubber heater is the hot face of a large platen used in making counter tops and cabinets.

68. A silicone rubber heater is bonded to the side wall of a stainless steel tank to heat degreasing solvents in an ultrasonic bath.

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



Case history 69

70. Tires of drag race vehicles require pre-heating to improve traction. Silicone rubber 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, Polyimide (Kapton®), neoprene, or HT foil, Watlow has the answer to apply heat precisely where it is needed.

Let Watlow be your heat solutions resource.

Applications

Semiconductor

- Chucks
- Gas lines
- Pump lines
- Valves

Life science (Medical)

- Blood and urine diagnostics
- Disease diagnostics
- Laboratory equipment
- Respiratory care and diagnostics

Satellite/communications

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

Industrial equipment

- Compressors
- Epoxy curing equipment
- Freon® reclamation
- Gensets
- Packaging equipment
- Photocopy equipment
- Any equipment with an enclosure that requires condensation or freeze protection

Precision cleaning

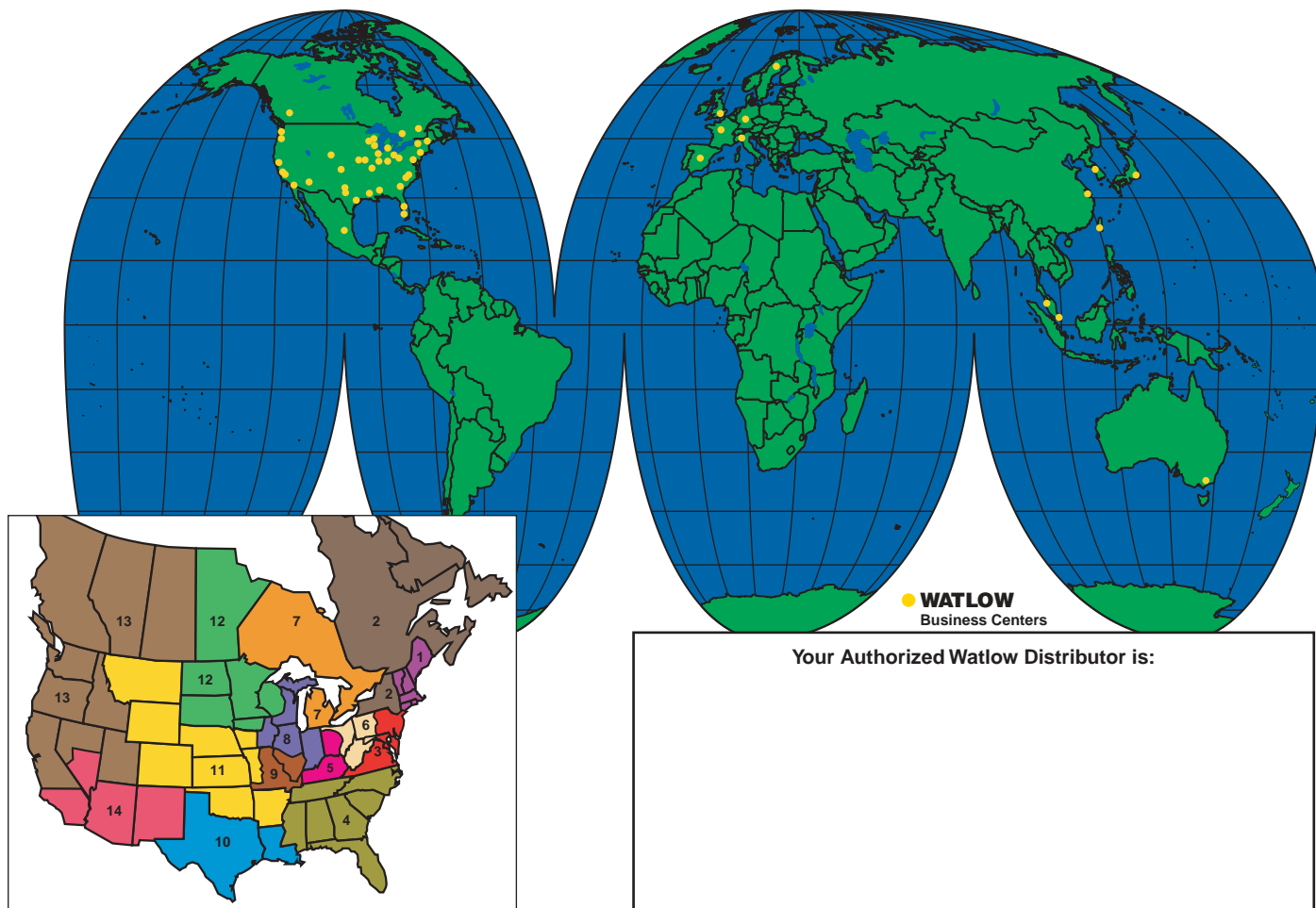
- Laboratories
- Supplemental heat to direct immersion

Foodservice equipment

- Coffee makers
- Fryer grease traps
- Warming tables



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