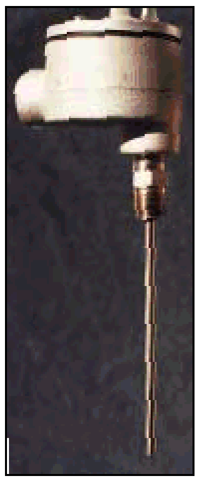
THERMISTOR TYPES

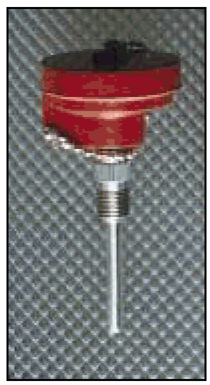
Thermistors can generally be classified into two major groups depending upon the method by which electrodes are attached to the ceramic body.

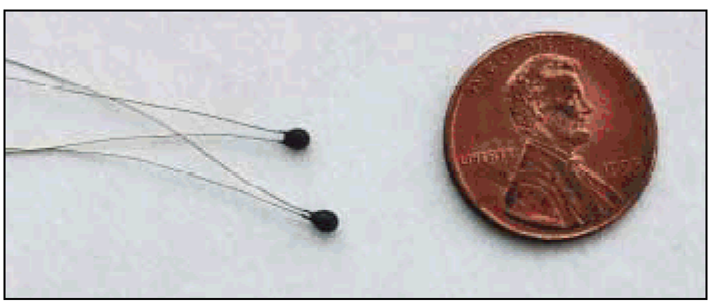
The first group consists of bead type thermistors. Among this group are bare beads, glass coated beads, ruggedized beads in a glass probe, and beads in a glass rod. All of the bead type thermistors have platinum alloy lead wires which are sintered into the ceramic body.

The second group of thermistors have metalized surface contacts. The most popular thermistors among this group are chips and flakes. These thermistors are available with or without lead wires attached to the metalized surface contact.

The bead type thermistors are fabricated by placing a small portion of mixed metal oxides with a suitable binder onto a pair of parallel platinum alloy lead wires, which are under a slight amount of tension. After the mixture has been allowed to dry, or has been partially sintered, the strand of beads is removed form the fixture and sintered in a tubular furnace. The metal oxides shrink onto the platinum lead wires during this sintering and form intimate electrical bonds. The beads are then individually cut from the strand in one of the desired lead wire configurations. The beads may be left bare or they may be given an organic coating; however, for best stability the beads are hermetically sealed in glass. This can be a thin glass coating or a thicker, ruggedized glass coating. The bare bead can also be welded to larger diameter lead wires and sealed into a glass tube to form a rod or probe type thermistor. The metalized surface contact type thermistors are fabricated by several different methods depending upon the basic geometry of the device. Chips are manufactured using a tape casting process while flakes are either bladed and cut into individual devices or they are screen printed. Once the desired geometry has been obtained, the devices are sintered. The metalized surface contact is then applied by spraying, painting, screen printing, or dipping as required and the contact is fired onto the ceramic body. Metalized surface contact type thermistors can be obtained with or without leads. The leads can be attached in various configurations depending upon the geometry of the device. Devices such as the chips can be ground to precision resistance tolerances at controlled temperatures after the leads are attached. A variety of organic coatings are available for the metalized surface contact types and recently, glass enclosed chips have been introduced.







THERMAL PROPERTIES

When a thermistor is connected in an electrical circuit, power is dissipated as heat and the body temperature of the thermistor will rise above the ambient temperature of its environment. This can be expressed as:

$$T = T_A + \Delta T$$

where T is the temperature of the thermistor; Ta is the ambient temperature; and ΔT is the rise in temperature due to the power dissipated in the thermistor. The rise in the temperature, ΔT, is also known as the "self-heating" effect and is a major consideration in precision resistance thermometry applications.

When power is applied to a thermistor, or any physical device, the rate at which energy is supplied must equal the rate at which energy is lost plus the rate at which energy is absorbed (the energy storage capacity of the device).

$$\frac{dH}{dt} = \frac{dH_L}{dt} + \frac{dH_A}{dt}$$

The rate at which thermal energy is supplied to the thermistor in an electrical circuit is equal to the power dissipated in the thermistor.

$$\frac{dH}{dt} = P + I^2R = EI$$

The rate at which thermal energy is lost from the thermistor to its surroundings is proportional to the temperature rise of the thermistor.

$$\frac{dH_L}{dt} = ç\Delta T = ç\ (T - T_A)$$

The dissipation constant, c, is defined as the ratio, at a specified ambient temperature, of a change in the power dissipation in the thermistor to the resultant body temperature change. The dissipation constant depends upon the thermal conductivity and relative motion of the medium in which the thermistor is located, as well as the heat transfer from the thermistor to its surroundings by conduction through the leads, by free convection in the medium and by radiation. The dissipation constant is not a true constant since it varies slightly with the temperature and also with temperature rise.

The rate at which thermal energy is absorbed by the thermistor to produce a specific amount of rise in temperature can be expressed as follows:

$$\frac{dH_A}{dt} = \frac{smdT}{dt} = \frac{CdT}{dt}$$

where 's' is the specific heat and 'm' is the mass of the thermistor. The product of the specific heat and mass of the thermistor is the heat capacity, C, of the thermistor, and is dependent upon thermistor construction.

By substitution, we can arrive at the heat transfer equation for a thermistor at any instant in time after power has been applied to the circuit.

$$\frac{dH}{dt} = P = EI\ ç\ (T - TA) + C\frac{dT}{dt}$$

Thermistors which have very close resistance tolerances and which can be readily substituted without the need for circuit adjustments and recalibration are called "Interchangeable." Very often these devices have curve tolerances which are expressed as a temperature uncertainty. When the curve tolerance is so expressed, the resistance limits at the low temperature point will be slightly greater than the resistance limits at the high temperature point. This is due to the greater values for the temperature coefficient of resistance (alpha) at lower temperatures. It follows then, that when curve tolerances are given as a resistance uncertainty, the temperature uncertainty will be lesser at the low temperature point and greater at the high temperature point.

PROPERTIES OF THERMISTORS

Thermistors have thermal and electrical properties which are important consideration in each application. Or type of thermistor device and a nominal resistance has been selected, the manufacturer will prepare a mixture of r oxides in proper proportions to achieve the desired results. Such a mixture of metal oxides is referred to as the "m ial system" of the thermistor. The basic thermal and electrical properties are now fixed for the material system and mistor structure selected.

JMS Southeast, Inc. maintains a system of quality assurance which complies with MIL-Q-9858. All of our beac chip thermistors are designed to comply with MIL-T-23648.

Every JMS thermistor is 100% physically and electrically inspected. The following tables give some typical apı tion of thermistors based on resistance versus temperature characteristics:

THERMISTOR APPLICATIONS BASED ON R-vs-T CHARACTERISTICS

(Temperature Measurement & Control)

General Industrial Applications
Industrial Process controls
Plastic Laminating Equipment
Hot Glue Dispensing Equipment
Auto & Truck Tire Curing
Fiber Processing & Manufacturing
Pyrometers (Non-contract)
Photographic Processing
Copy Machines
Soldering Irons (Controlled)
Hot Mold Equipment (Thermoplastics)
Solar Energy Equipment

Consumer Appliances and Household Applications
Thermostats
Small Appliance Controls
Burglar Alarm Detectors
Oven Temperature control
Refrigeration & Air conditioning Equipment
Fire Detection

Medical Applications
Fever Thermometers
Dialysis Equipment
Rectal Temperature Monitoring
Myocardial Probes
Esophageal Tubes
Skin & Muscle Temperature
Thermodilution Catheters
Respiration Rate Measurement
Blood Analysis Equipment
Respirators
Hypodermic Needle Probes
Fluid Temperature

Instrumentation Applications (Compensation)
Motor Winding Temperature Compensation
Infrared Sensing Temperature compensation
Instrument Winding Temperature Compensation

Automotive and Transportation Applicatioı
Emission Controls
Differential Temperature Controls
Fire Protection and Safety Equipment
Engine Temperatures
Aircraft Temperatures
Rotor/Bearing Temperatures

Laboratory & Scientific Applications
Temperature Standards
Chemical analysis
Oceanographic Research
Meteorology
Bathythermography
Calorimetry
Titration Studies
Geological Temperature Studies
Spectrophotometers
Bolometry
Osmometers

Food Handling Applications
Fast food Processing
Perishable Shipping
Oven Temperature control
Food Storage
Coffee Makers
Freezing Point Studies

High Reliability and Military applications
Missiles & Spacecraft Temperatures
Aircraft Temperatures
Submarines & Underwater Monitoring
Fire control Equipment

Communications Applications
Transistor Temperature Compensation
Gain Stabilization
Piezo Electric Temperature Compensation
Ambient Temperature Compensation