Thermocouples vs Thermistors

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THERMOCOUPLES ISSUES

Thermocouples seem to have been the gold standard in cold fusion calorimetry. It is not necessarily true that thermocouples provide an improvement over thermistors. In fact, there is much evidence in the literature and on sci.physics.fusion that thermocouples caused many problems in early cold fusion experiments, including difficulties isolating them from electrical noise, electrochemical potentials, and other effects associated with low deg./volt ratios. The more important issues are calibration and choice of experimental controls.

It is important to note that thermistors come in various sizes and resistances. The more common type are 10K ohm, but 100K ohm are common also. A 100K thermistor operated at 1 volt will push only 10^-4 watts through it. The significance of that 10^-4 watts depends upon the environment the thermistor is placed in. If the thermistor is placed or glued on a metal surface, for example, then that heat 10^-4 W is rapidly diffused and plays no significant part in the temperature reading. Further, it is possible to measure the resistance of the thermistor in a bridge configuration, in a manner similar to that used to balance against a small thermocouple voltage, and to do so passing only a nominal current through the resistor - by using amplification similar to that required by thermocouples. If the sample voltage is 10^-3 volts, then the "read" power is only 10^-7 W. The thermal effect can be diminished by orders of magnitude by pulsed or multiplexed reading.

It is notable that the energy from thermocouples is sometimes taken from the environment being measured, depending on the circuitry employed. If the thermocouple either generates current or passes current then this affects its local thermal environment just as current passing through a thermistor does, but the thermal effect is not simply dependent upon resistance, but rather on the junction dynamics. A thermocouple will pass such current unless the amplifier used to track the thermocouple voltage instantaneously adjusts its voltage to oppose that voltage generated by the thermocouple. Thermocouples are often operated as one leg of a bridge, but if the bridge parameters are not instantaneously updated to track the thermocouple voltage, then temperature disturbing currents result.

Another major problem experienced in cold fusion experiments was "thermal wicking," an effect which hinders accuracy for thermocouples, thermistors, and bulb thermometers, but usually is worst for bulb thermometers. This thermal wicking effect is the tendency of the thermometer "stem" to conduct heat to or from the environment to the site of measurement, and to increase the thermal time constant of the thermometer. Thermistors or thermocouples can (but do not necessarily) use thin wires and thermal insulation to achieve a high stem thermal resistance and a low stem specific heat.

There is no substitution for calibration, experimental control and careful experiment design.

DIRECT TEMPERATURE DIFFERENCE MEASUREMENT

For direct temperatuere differential measurement one might want to consider using a type T thermocouple. (See p. Z-31 of OMEGA's "Temperature Handbook" and ASTM special publication 470A, "Manual on the use of Thermocouples in Temperature Measurement", Omega Press, Stamford CT, 06907, 1974.)

The standard configuration looks like Fig. 1 below

```
   +            Cu
     o---------------------
                           \
                            o  T1
                           /
                          |
    V=a(T1-T2)            |  Constantan wire
                          |
                          |
                           \
                            o  T2  (ambient reference)
                           /
     o---------------------
   -            Cu
```

Fig. 1 - Temperture Difference Measurement

This thermocouple system has the unique property that the main leads are copper, thus making lead compensation unnecessary if connected to copper terminals. The wire error table indicates an error of less than one deg. C absolute, but the differential error is well under 0.75 percent. Since the voltage function is V=a(T1-T2) it is easy to check the zero point at lots of temperatures, and even to check the constant "a" across the temperature range to be sure it is constant.

This configuration avoids zero drift problems associated with direct temperature measurement, and obtains great accuracy due to the *difference* (T1-T2) being measured.

THERMISTORS

Using the hishest resistance thermistors available helps reduce thermistor disruption to the environment bein measured. BetaTherm 100K6A thermistors are useful, but require use of a nonlinear formula to convert resistance to temperature. This formula is the Steinhart-Hart equation, which is described at:

<http://www.betatherm.com/stein.html>

The Steinhart-Hart equation, accurate to 0.01 C, is:

$$1/T = A + B (\ln R) + C (\ln R)^3$$

where T is in Kelvin, R is in ohms, and the coefficients A, B and C are:

A=8.271111x10-4, B=2.088020x10-4, C=8.059200x10-8

derived from data at 08 deg. C, 25 deg. C and 70 deg. C. The source for the above is:

<http://www.betatherm.com/stein_coeff.html>

There may be very minor differences in individual thermistors and this can be compensated for by measuring in the range used and then adding a small constant value to T. They are typically accurate to 0.2 K on an absolute basis, but show sensitivity to small incremental changes as low as 0.01 K.

Thermistors will permanently drift if exposed to temperatures over 90 C, and there are compensating formulas for that drift if the exposure time to high temperature is known. Exposure over 1 month obtains maximum permanent drift.