

ME 372

Temperature Measurement Using the Resistivity of Copper

Introduction

A thermometer is a device that has at least one property that is dependent upon temperature. In this laboratory a simple thermometer will be constructed using copper wire to measure the decrease in temperature.

Procedure

1. Construct Thermometer

- a) Cut to length the 40 gauge copper wire. The length must be carefully measured so that the overall resistance of the copper wire is between 30 to 40 ohms. Table 1 shows the resistance characteristics of both the 18 and 40 gauge copper wires.

Table 1: Copper Wire Characteristics

Wire Gauge	Diameter (cm)	Cross Sectional Area (cm ²)	Resistance (ohms per ft @ 20° C)
18	0.102	0.00823	0.006
40	0.008	0.0000501	1.049

- b) Carefully wrap the 40 gauge copper wire into a 2 – 3 inch coil around one end of the thin glass tube. Make sure to leave at least two inches of loose wire at each end of the copper wire as shown in Figure 1.

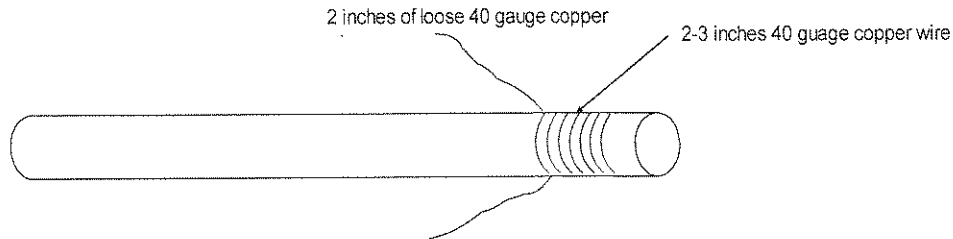


Figure 1: Initial stage of resistance thermometer construction

- c) Cut two 3 ft pieces of 18 gauge copper wire. Clean all copper ends with sand paper. Solder one piece of 18 gauge copper wire to each loose end of 40 gauge copper wire as shown in Figure 2.

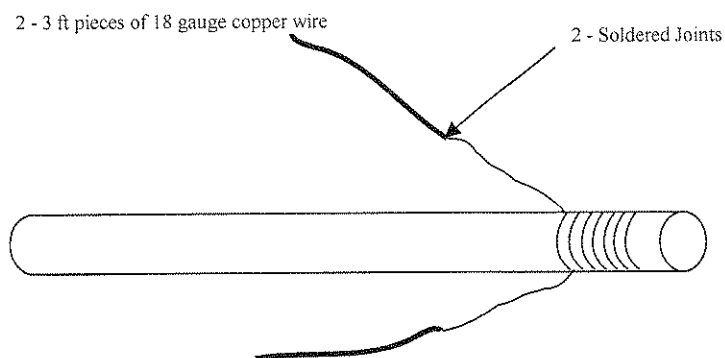


Figure 2: Second stage of resistance thermometer construction

- d) To ensure the integrity of the soldered joints, secure the joints to the glass tube with black tape as shown in Figure 3.

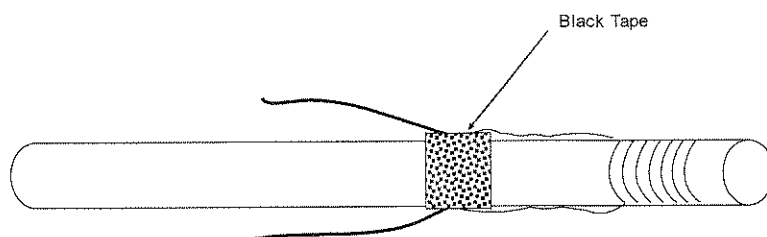


Figure 3: Completed thermometer

- e) To ensure proper function, connect the thermometer to an ohmmeter to measure the resistance. If the signal is between 10 to 100 ohms a good resistor has been constructed.

2. Experiment

- a) Heat water in a beaker to 100 °C using the Bunsen burner. Place both copper and mercury thermometers into the hot water. Let both thermometers stabilize and then take first measurement.
- b) Slowly add cold water (and/or ice) to decrease temperature and continue to take measurements at 5-10 °C intervals down to 0 °C.

- c) Remove both thermometers from the cold water and place the copper thermometer and a special cold thermometer into an empty beaker. Add a small amount of dry ice to the empty beaker. Let the temperature stabilize and take a single reading from both thermometers.

Make sure that you have taken at least ten measurements throughout the experimental procedure.

Results and Calculations

1. Plot the copper thermometer results as a function of temperature (mercury thermometer). ***Show your plot to the TA before you leave the lab.***
2. Extrapolate the experimental results to cover the range in temperature between 150 and -273 °C.
3. Calculate the resistivity for each data point and plot resistivity versus temperature.
 - a) Find an equation for the resistivity as a function of temperature through a least squares analysis.
 - b) Use this equation to calculate the resistance at 0 °K.

Discussion

1. How well did a least squares analysis fit the experimental data?
2. Was any non-linear behavior observed? What might have been some potential causes?
3. Can the experimental equation be extrapolated (with confidence) to determine resistance over a wider range of temperatures? Explain.
4. Compare your plot of resistivity versus temperature to handbook values (*Materials Science and Engineering an Introduction*, Callister, 7th Ed., pp. 675).
5. When electric current is passed through a thin wire of length l and area, A the resistance is given by:

$$R = \rho l / A$$

where ρ is the resistivity of the metal. With l and A known from Table 1 for the 40 gauge copper wire and ρ for copper at room temperature being equal to 1.7×10^{-8} ohm-meters, what is the predicted resistance of the copper wire? How does this compare to the measured value?

Laboratory Reporting Format

All reports will be written in a formal format that includes an abstract, introduction, procedure, results and discussion sections. Any references used in the body of the report must also be sighted at the end in a reference section.

One report per lab group will be permitted.