Application Note 1085-152

Non-smooth Specific Heat Between 200 K and 300 K due to Anomalous Specific Heat of Apiezon N-grease

Problem Description

A small amount of Apiezon N-grease was placed on the heat capacity platform and an addenda measurement was obtained with a coarse temperature spacing in the range of 200 K to 300 K as shown in Figure 1. A 20 mg sample of copper was pressed onto the grease and a high-resolution measurement was obtained as shown in Figure 2. The expected values from the literature are also shown for comparison. Note that the data is not very smooth in this range and is rather non-reproducible in the 290 to 300 K range.

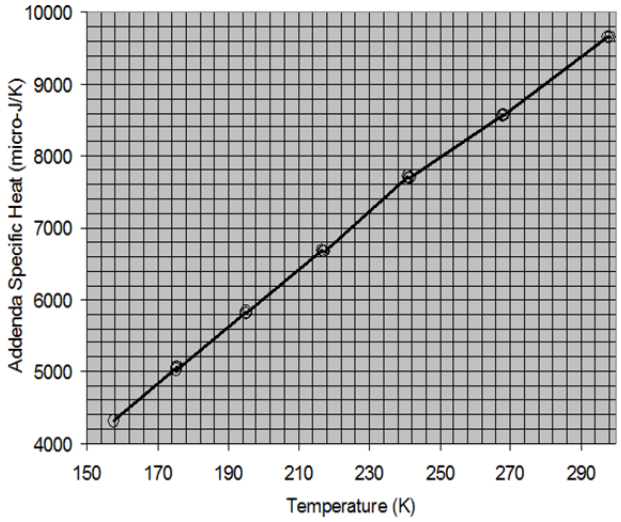


Figure 1: Specific heat of the addenda with a small about of N-grease on the platform. Note the large temperature spacing between points and the anomalous point at 240 K.

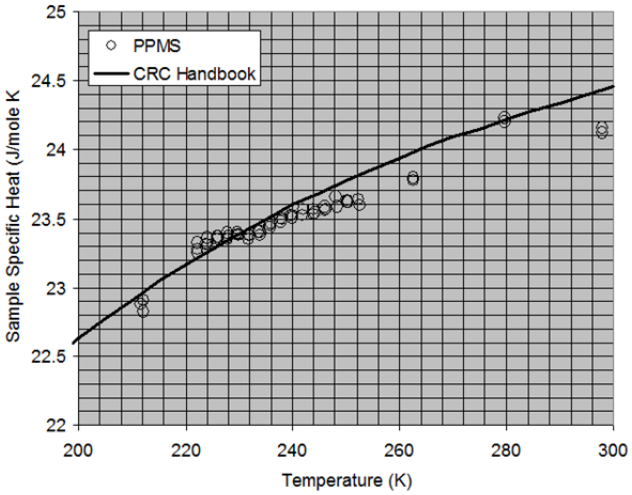


Figure 2: High-resolution specific heat measurement of 20 mg copper using the coarse addenda measurement above.

Explanation

The anomalous behavior of N-grease in this temperature range has been documented in the literature (see Bunting, et al, Cryogenics, Oct. 1969, pp. 385-386.) and is shown in Figure 3. The same authors report that the specific heat measurements are reproducible to about 1% between 200 K and 260 K, but only reproducible to about 5% between 260 K and 324 K.

When the addenda in Figure 1 was obtained, the specific heat of the N-grease was clearly under-sampled. When this under-sampled data was then subtracted from the total heat capacity values in the software to obtain the specific heat measurements shown in Figure 2, the anomalous features in the specific heat of the N-grease appeared. If the addenda measurement had been performed with a smaller spacing in temperature, the temperature-by-temperature subtraction of the background would have yielded the true specific heat of copper. In this temperature range, the heat capacity of the sample is about the same as the heat capacity of the addenda.

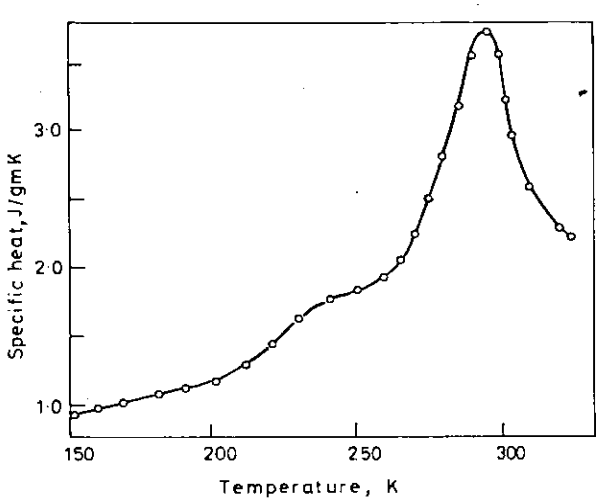
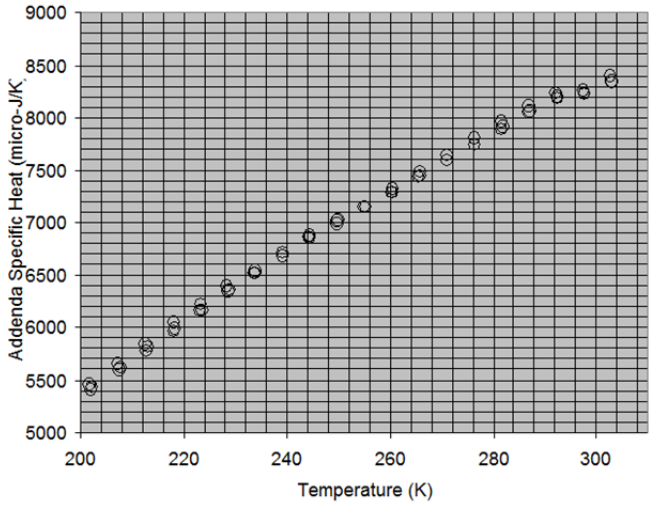
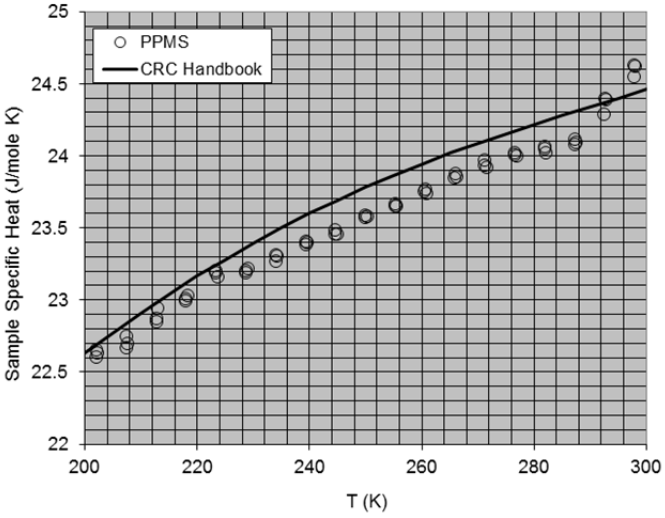


Figure 3: The anomalous behavior of the specific heat of N-grease (copied from Bunting, et al).





Solution

Apiezon H Grease has good properties for higher temperature measurements. Since it doesn't melt like N Grease, its specific heat is smooth and reproducible. However, it is more difficult to handle at room temperature, because it does not "wet" the surfaces of the platform or sample very well. Also, at temperatures below 200 K, H Grease has a tendency to spontaneously pop off. So for the best results, use H grease for measurements above 200 K. For information on the heat capacity of both N and H Grease, refer to "Heat Capacity of Apiezon H Grease from 1 to 50K" by A.J. Bevolo (Bevolo 1974).

If you need to work over the entire temperature range, N Grease is probably the best choice. Although smoothness and accuracy will be worse than with H Grease in the range of the anomaly (260 K to 325 K), overall, the results will be better than H Grease since there will be no loss of grease from it popping off. Improved results can be obtained with N Grease by using the smallest possible amount of grease to hold the sample. Also, the addenda measurement sampled at 5 K intervals between 200 K and 325 K is adequate to eliminate this under-sampling problem.

To summarize:

- Use N Grease at temperatures< 200 K.
- Use H Grease at temperatures> 200 K.
- For measurements over the entire temperature range, use N Grease and refer to the above discussion.