FURTHER INVESTIGATIONS INTO THE PERFORMANCE OF COPPER POINT STANDARD RESISTANCE THERMOMETERS[1]

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Abstract

At Tempmeko 2010 and T-9 we reported the successful design and development of a prototype SPRT working to 1100°C.

Before commercialising such a device two further SPRT's of slightly different design have been produced and evaluated. In this paper we report the results of tests on the two thermometers and compare them with the original design.

We conclude that the design is robust and the thermometers are fit for purpose.

Keywords: Copper Point, Thermometer

Introduction

In order to accurately characterise copper fixed point cells for contact thermometry, an accurate and stable thermometer working to 1100°C is required [3].

A review of current designs was therefore undertaken. Researchers have identified a number of problems and solutions, from which the author developed a novel design.

A prototype was built and evaluated; the results were reported at Tempmeko 2010 and T-9 in 2012 [1-2].

Description of the Prototype

The thermometer model 108462 is 480mm long, the sheath is alumina. The quarter ohm platinum sensor winding is held by a synthetic sapphire mandrel. Platinum loves oxidising and hates reducing atmospheres and so uniquely the new thermometer is pressurised with air so that any sheath leakage is outwards, maintaining an oxygen rich atmosphere around the winding.

Researchers have also shown that the thermometer needs to be biased to above +6.5V DC [4-5] which has two positive effects. Firstly the bias increases the insulation and secondly it repels metallic ions (for a more complete description the reader is referred to [1]).

Before offering the thermometer for sale, two further thermometers were built and tested to ensure the robustness and reproducibility of the design.

Design Features of the Two New Thermometers

As with the successful prototype the 0.25Ω Ro Platinum windings were wound onto synthetic sapphire mandrels. The four platinum lead wires were separated with tubes of quartz glass and passed through four bore spacers made of alumina in thermometer 006, and quartz in thermometer 005. The sheath was alumina 650mm long in both thermometers [1-3].

At elevated temperatures the winding was biased to +9V DC and the thermometers were aspirated enabling the internal gas to be changed at will.

Initial Annealing

The first tests on the two new thermometers were to cycle them to 1090°C for days and track changes in R_{TPW} and Wga. In normal annealing R_{TPW} drops and Wga increases. However, initially we did not attach the air pumps that pressurise the internals of 005 and 006. The result was that some contamination occurred characterised by an increase in R_{TPW} and a decrease in Wga. This happened during the first 350 hours of annealing and as can be seen, as soon as the pumps were attached the thermometers stabilised, and even partially recovered. See graphs 1, 2, 3 and 4.

After annealing, both thermometers have been successfully used to follow the melts and freezes of production copper cells and give good stable results, similar to the prototype 002. See graphs 5-11.

It will be noted that W_{Cu} for 005 and 006 are about 0.1°C equivalent lower than 002 accountable by the initial contamination. See graph 11.

Discussion

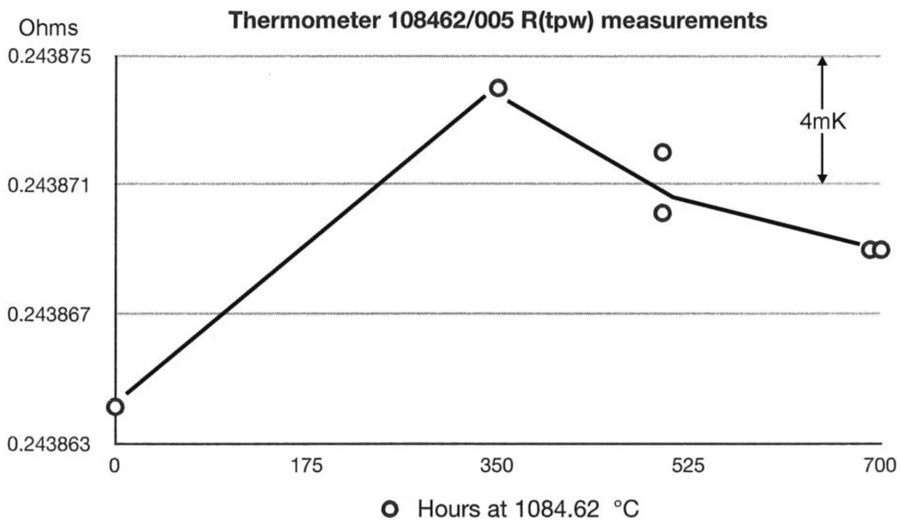
Results, confirm that the two longer thermometers perform as well as the prototype, the material of the spacers is not important but keeping the internal air pressure of the thermometers above ambient is vital to prevent contamination from the surroundings (the air pumps used give less than 1mb extra pressure).

Conclusion

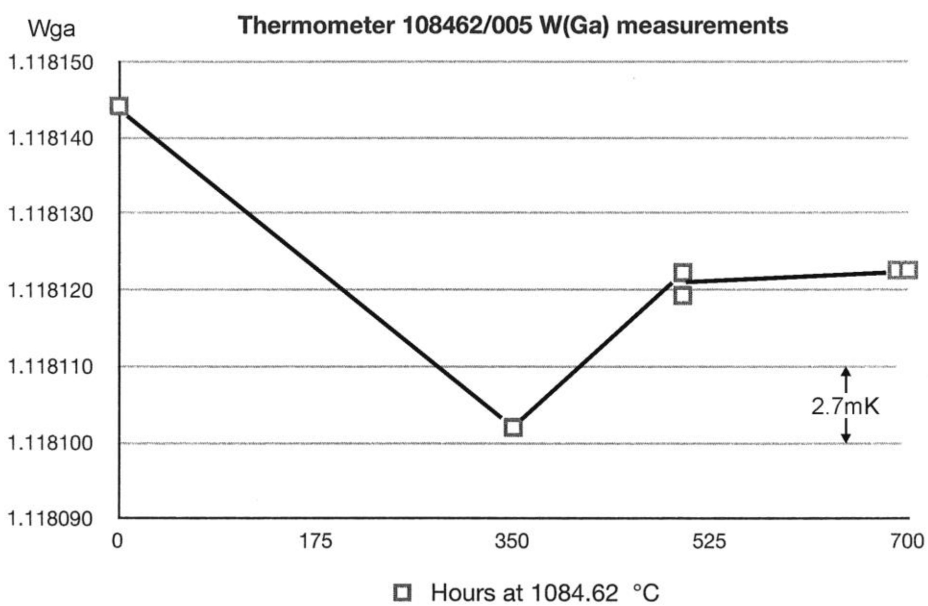
The key to stable high temperature resistance thermometry is the inclusion of an air pump that pressurises the inside of the thermometer. This creates an outward flux of air protecting the internal structure from contamination. In addition the +9V DC bias creates a Schottky barrier and an electric field that also repels ions.

All three thermometers have stable R_{TPW} Wga and Rcu and are suitable for characterising copper cells.

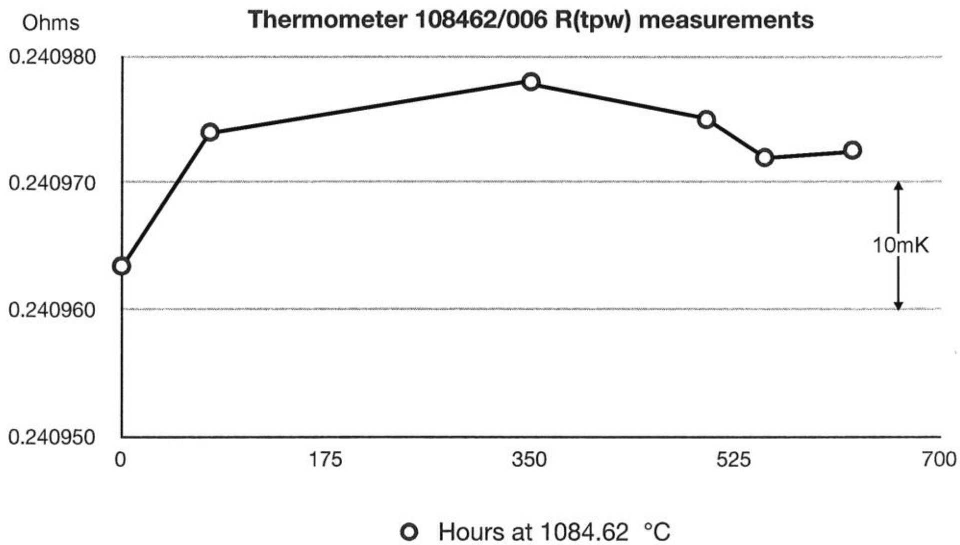
Graph 1



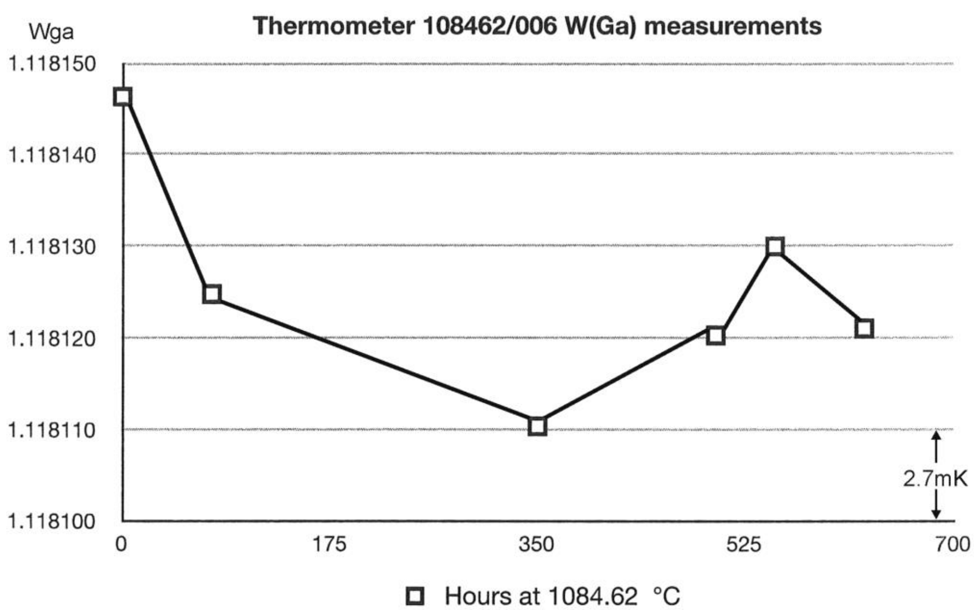
Graph 2



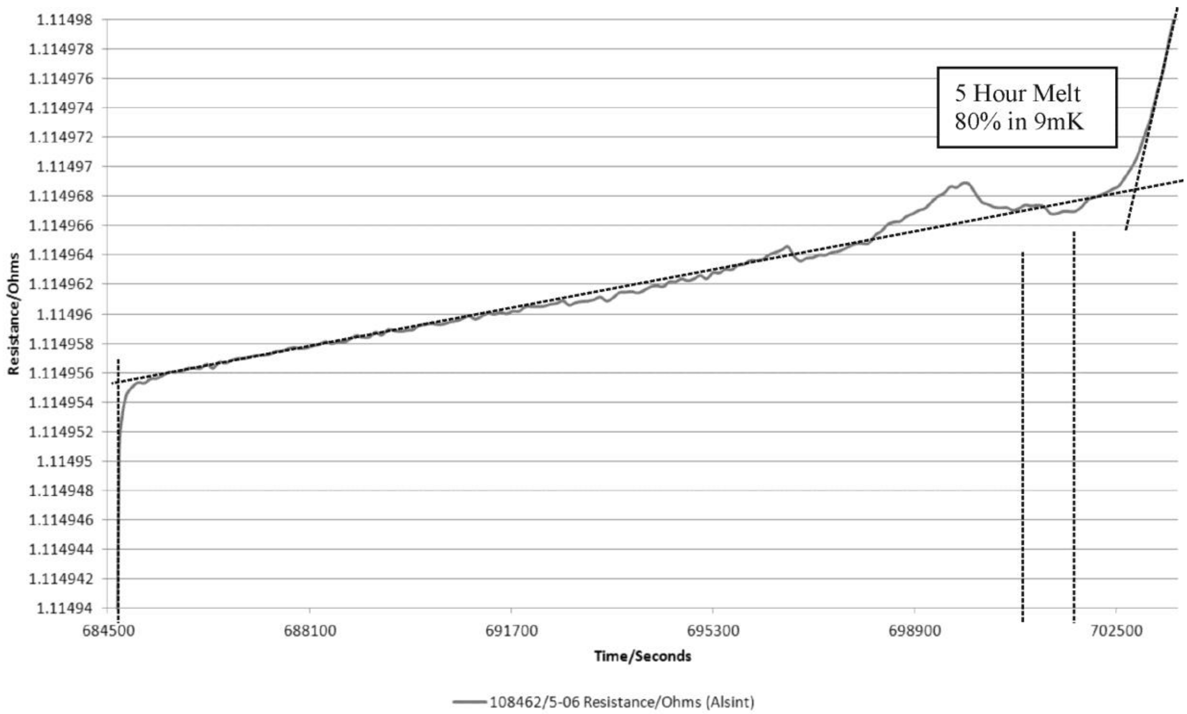
Graph 3



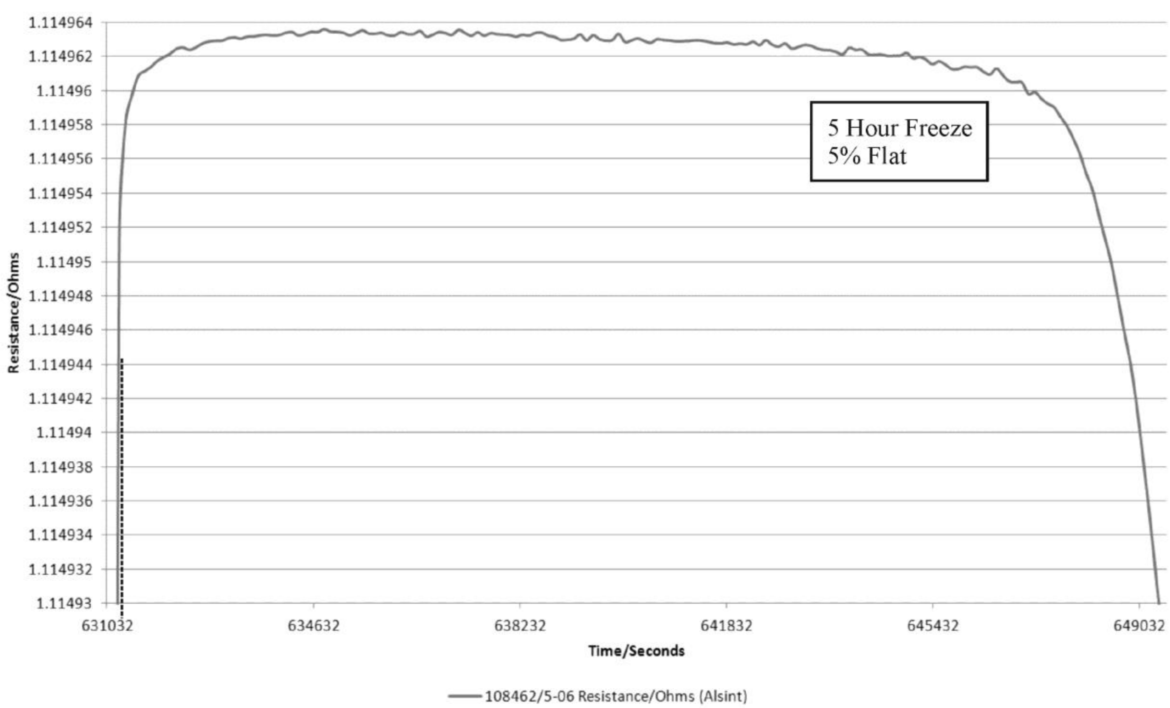
Graph 4



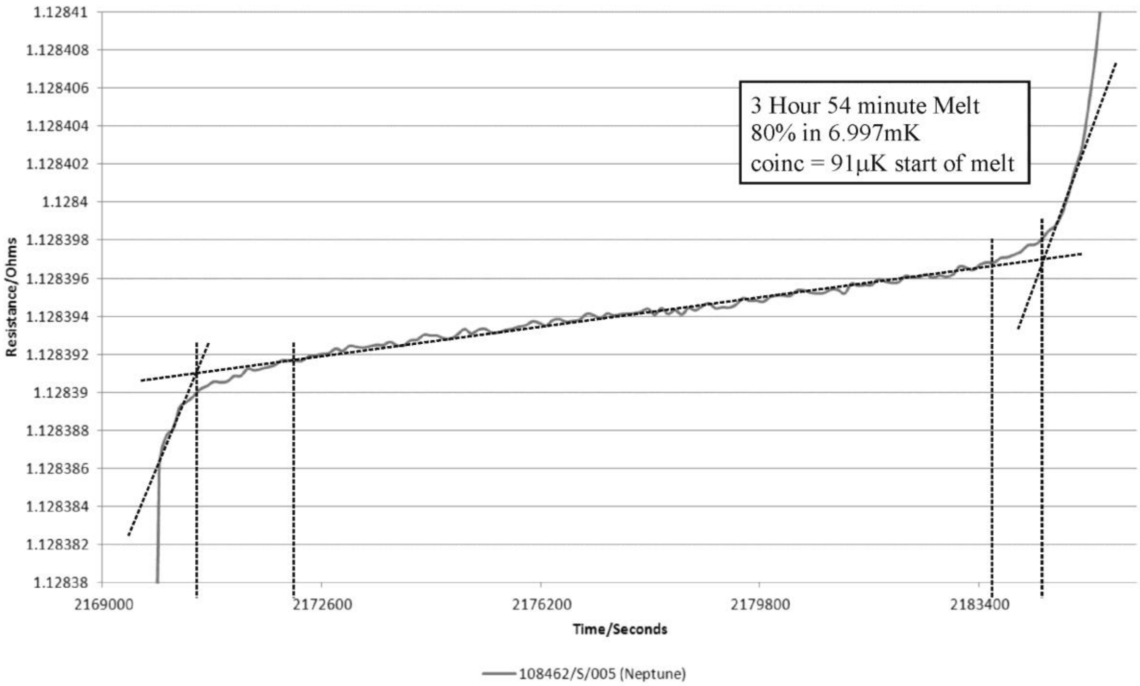
Graph 5



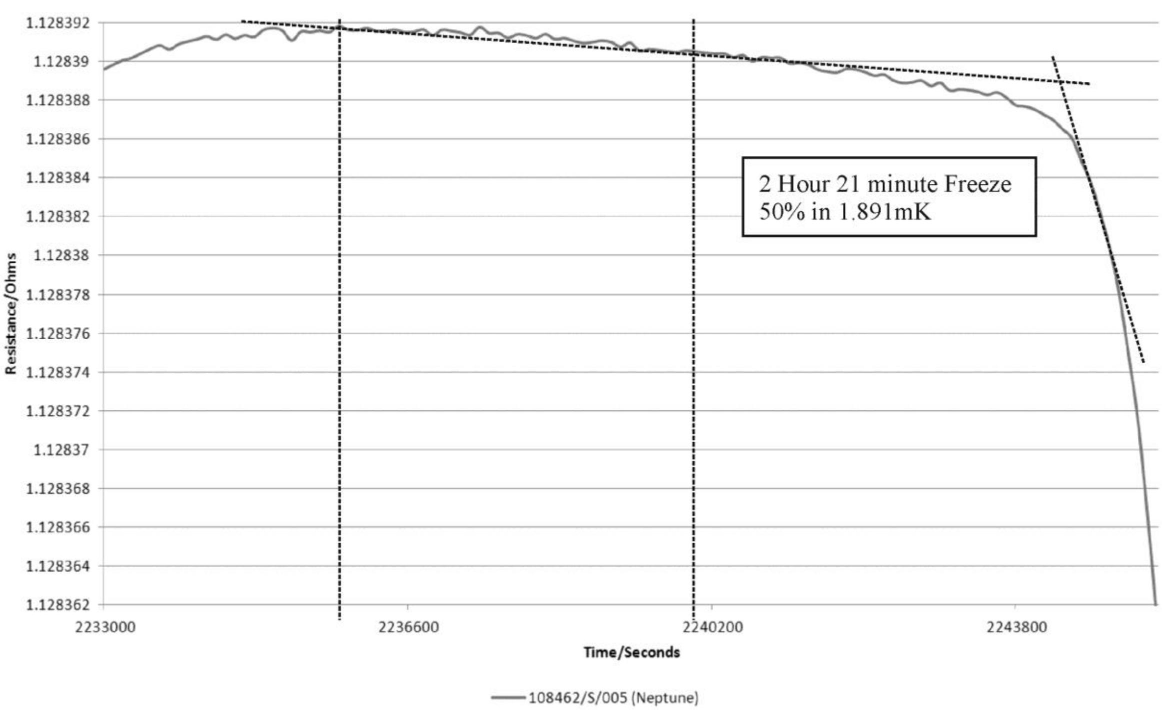
Graph 6



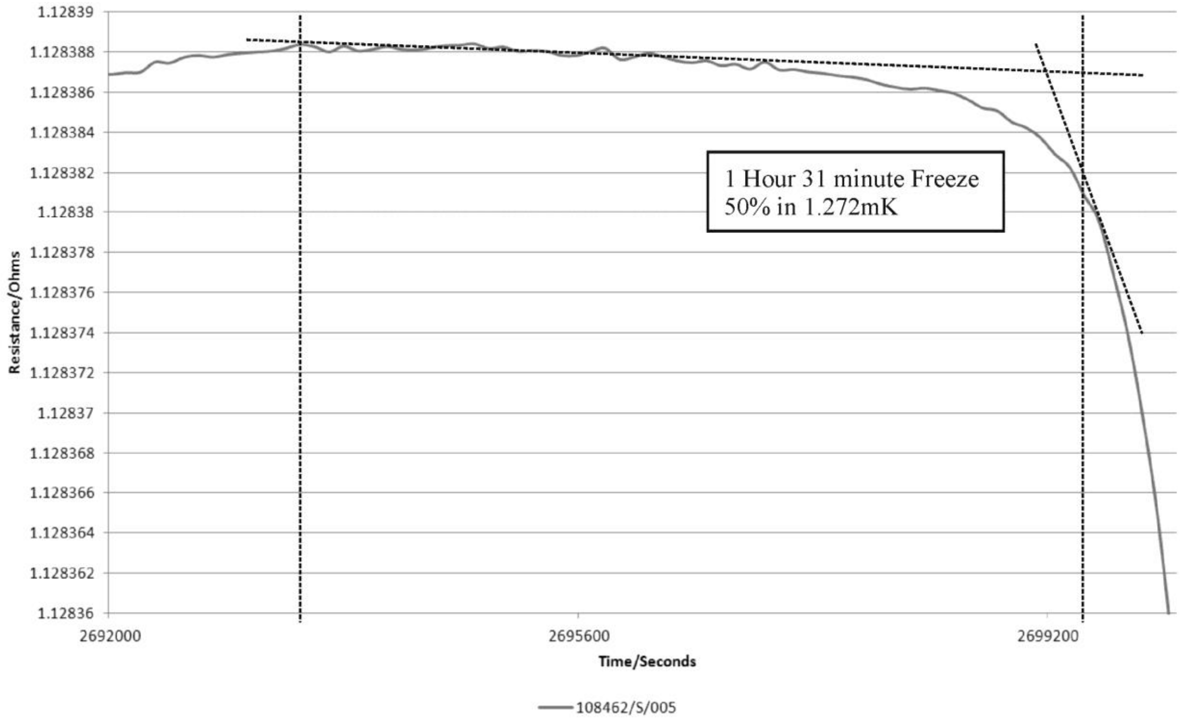
Graph 7



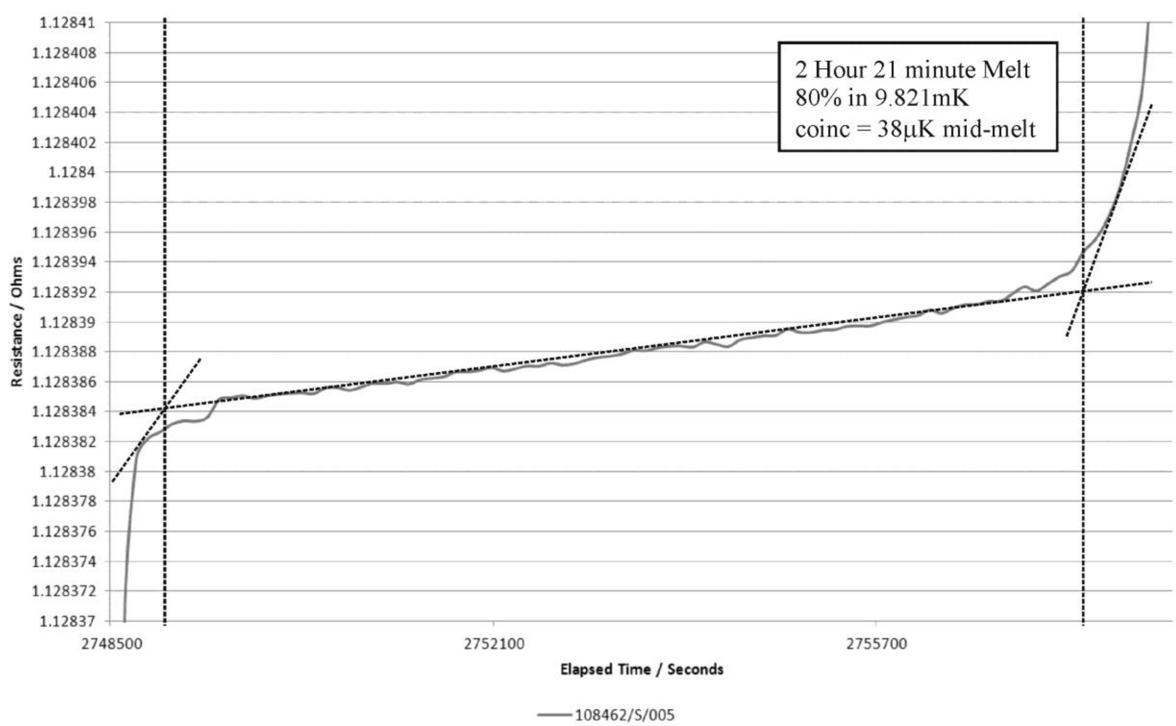
Graph 8



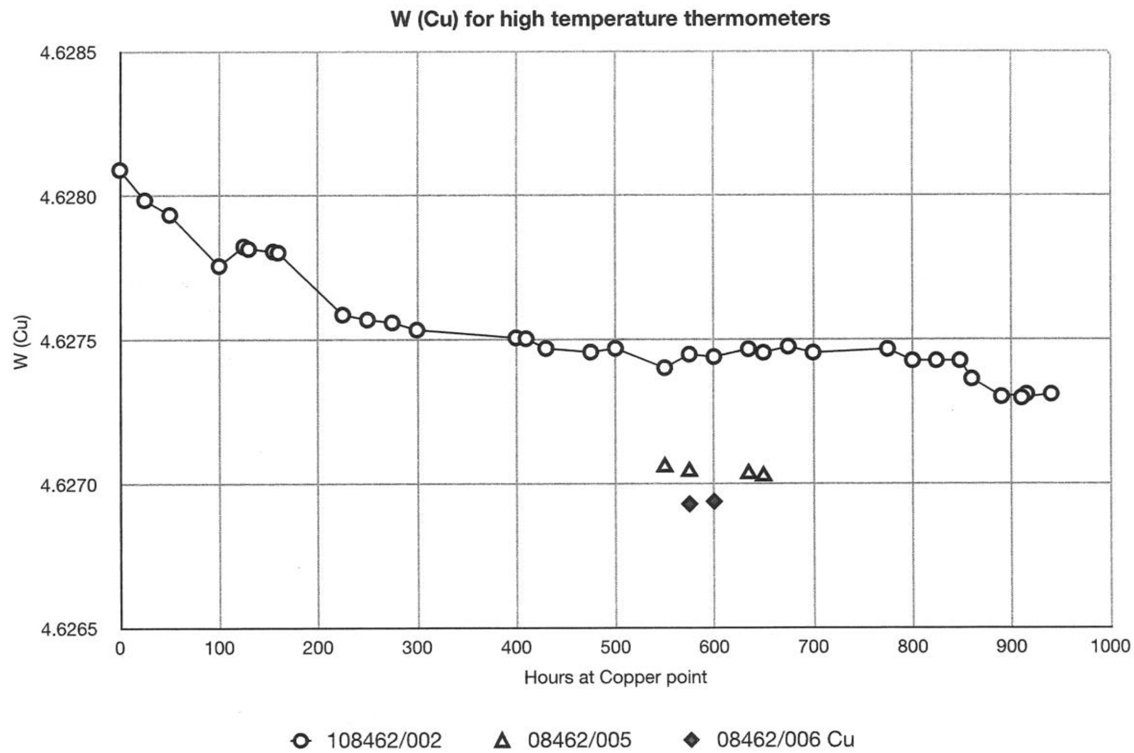
Graph 9



Graph 10



Graph 11



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