



**CALIFORNIA STATE SCIENCE FAIR
2007 PROJECT SUMMARY**

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Project Title
Lead-Free Solders: Are They All that They Are Cracked Up to Be?

Abstract

Objectives/Goals
There has been a push to make more environmentally safe products, such as solder. It is unknown if non-lead based solders have better or worse mechanical properties in comparison to lead based solders. This experiment asked the question: How will different solder alloys be affected by different temperatures as measured in relative fracture toughness?

Methods/Materials
A way to test the fracture toughness is to build an Izod Impact Tester that breaks the sample with a swinging hammer. Fracture toughness is inversely proportional to the distance the hammer travels past the breaking point. Test specimens made of four different alloys were cast using a mold in the shape of a pawn. Then the impact tester was built by attaching a hammer on a hinge, then attaching a variable resistor to measure the distance the hammer traveled. The test specimens were tested at room, freezer, ice bath, and dry ice bath temperature.

Results
The alloy that had the best relative fracture toughness was the lead-free alloy: 96.5%Sn 3.5%Ag. The 50%Pb 50%Sn lead solder alloy was third best, and the 95.5%Sn 3.45%Cu 1%Sb 0.05%Ag was the worst performer. The 50%Pb 50%Sn lead solder had increasing measurement variance as the temperature went down. The results did not support the hypothesis. The alloys with higher percentages of tin had higher fracture toughness.

Conclusions/Discussion
My hypothesis stated that the solders with higher percentages of tin would be more brittle, based on the fact that tin is a comparatively brittle metal at temperatures below 13 C. The hypothesis was incorrect. Based on data, the higher percentages of tin alloys were actually among the toughest compositions. The 95.5%Sn 3.45%Cu 1%Sb 0.05%Ag, and 50% Pb 50% Sn solder were the ones who had the poorest fracture toughness. In summary, I found that some solders are better than the common lead based solder, and those should be introduced into the market.

Summary Statement
This experiment asked the question: How will different non-lead based solder alloys be affected by different temperatures as measured in relative fracture toughness?

Help Received
I received help from my dad in the part that he thought of the idea for the variable resistor to measure the distance the hammer traveled.