defense Standardization Program

Lead-Free Electronics

United States Department of Defense

Impact of Pb-free on the Military

- Legislative mandates
- Market share
- Commercial components
- Reliability concerns
- Impact on readiness

Legislative Mandates

- EU legislation mandated no Lead
- China and other countries following suit
- CA and other states doing the same
- Japan culturally went to Lead-free (Pb-free) to be “green”
- Some US manufacturers “voluntarily” adopting Pb-free solder

Military Electronics

- Military & aerospace are “out of scope”

  Despite being “out of scope,” Pb-free solder is having a profound impact on the acquisition and sustainment of military electronics!

Market Share

Military <1%

Commercial Components

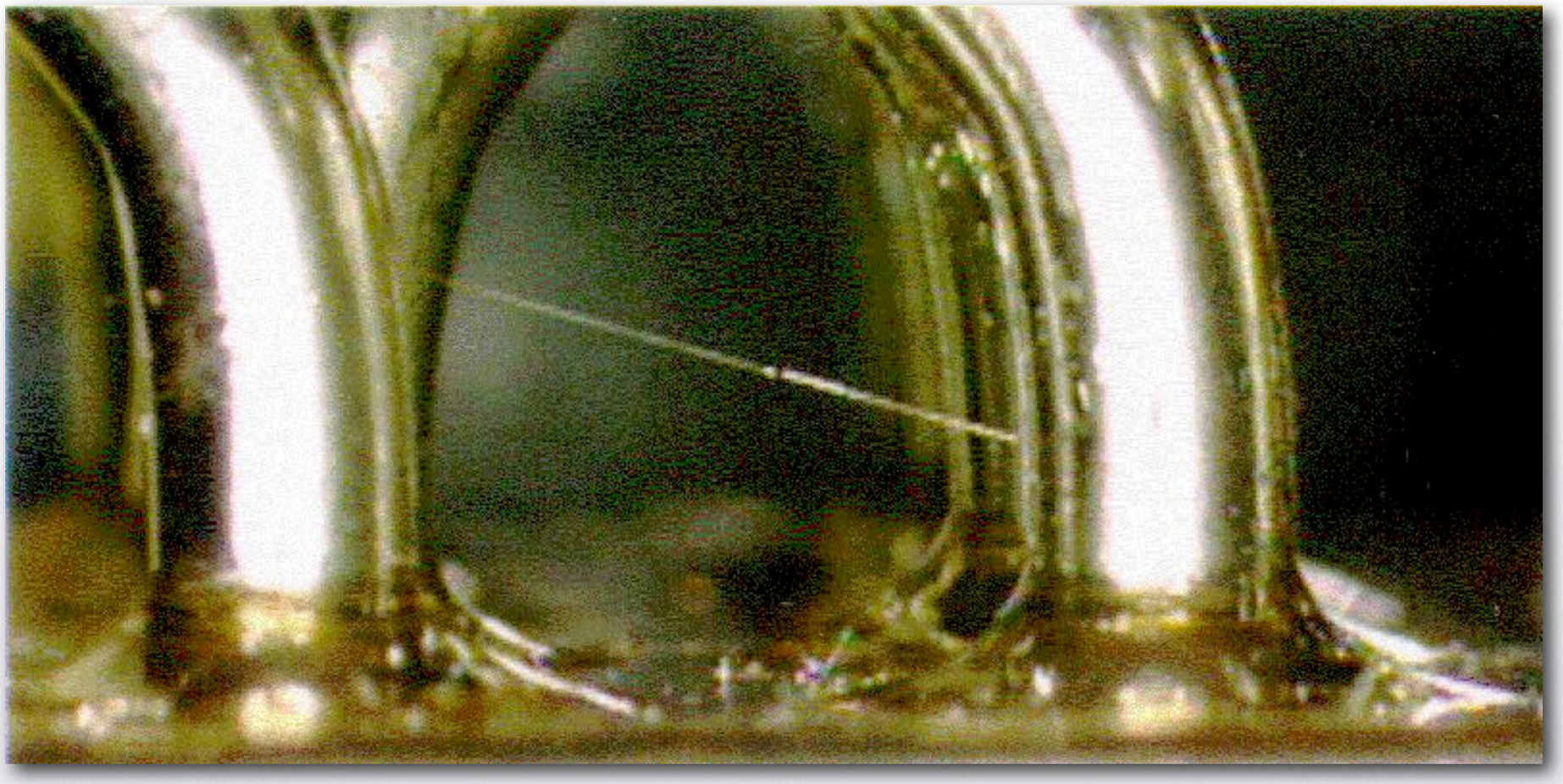
- DoD relies heavily on commercial components
- Most are now Pb-free
- Identification is difficult/expensive

Reliability Concerns

- Tin Whiskers
- Solder Joint Integrity
- Copper Dissolution
- Cross Contamination
- Processing Temperatures

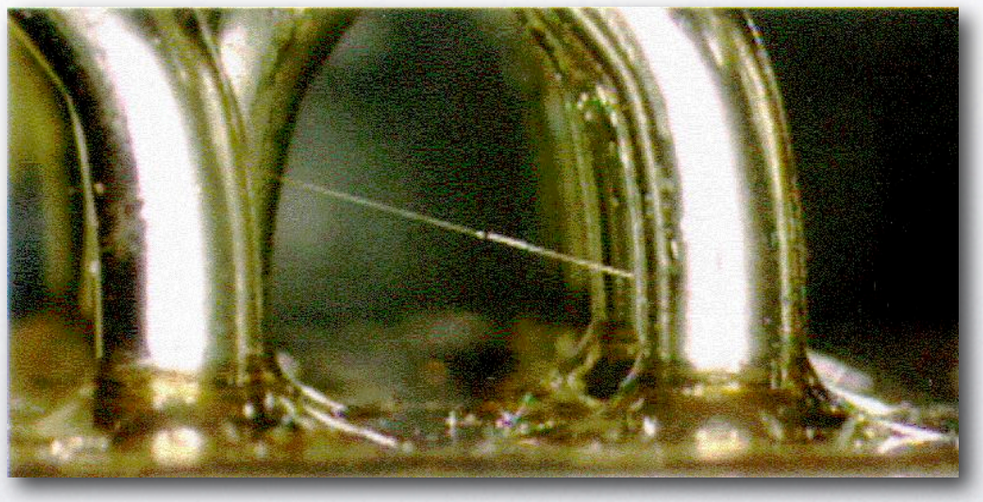
Tin Whiskers

- Electrically conductive, crystalline structures
- Can grow to lengths of several millimeters



Tin Whiskers

- Explanation as to cause not established
  - Compressive Mechanical Stress
  - Residual stresses caused by electroplating
  - Mechanically induced stresses
    - Induced by diffusion of different metals
    - Thermally induced stresses
- May cause electrical shorts and failures
- Can grow through conformal coatings

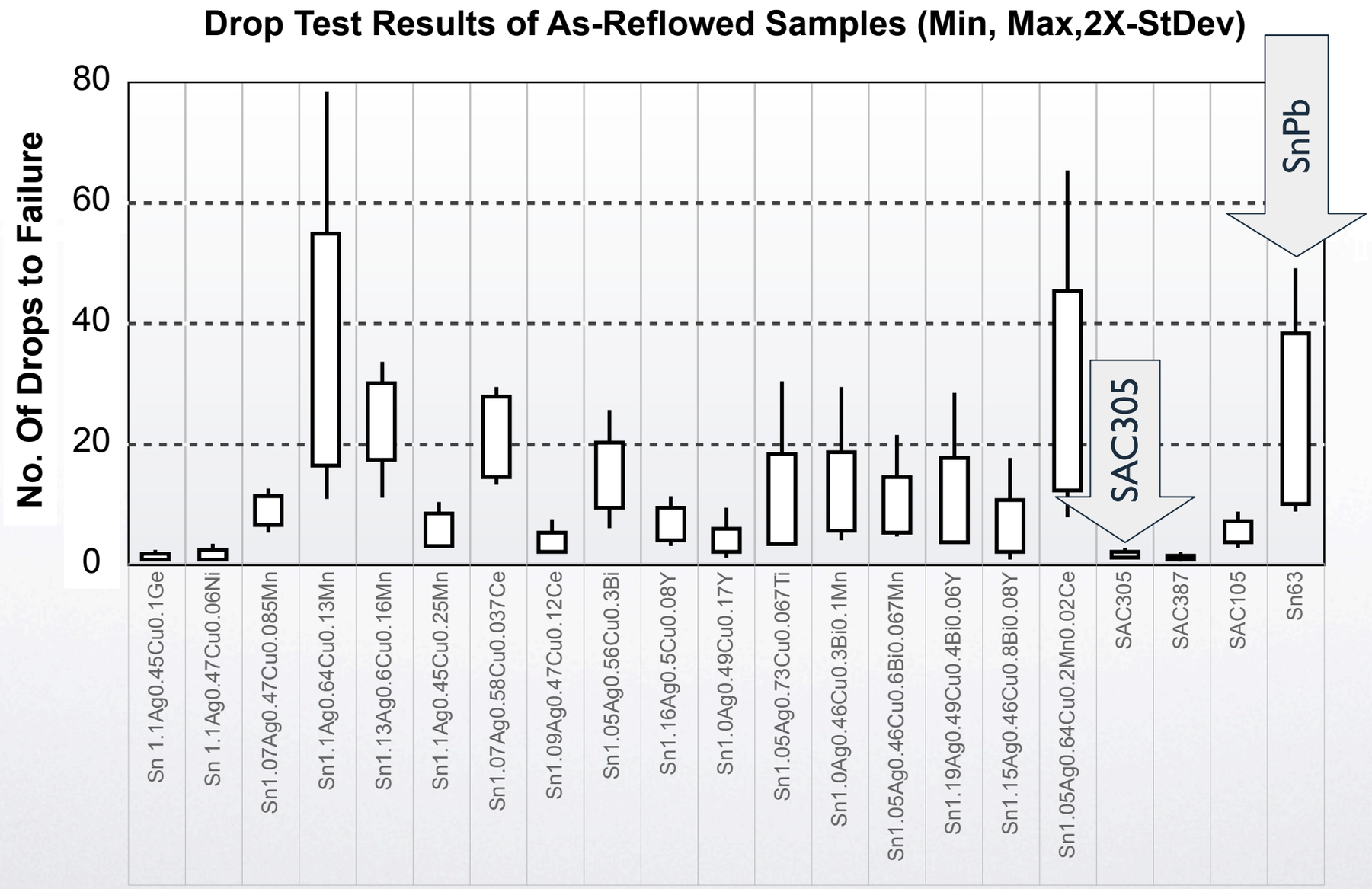


Solder Joint Integrity

Solder Joint Integrity

- Little long-term field reliability data on Pb-free in military environments
- Reliability of solder joint indications
  - Pb-free more than SnPb in low stress conditions
  - Pb-free less than SnPb in high stress conditions

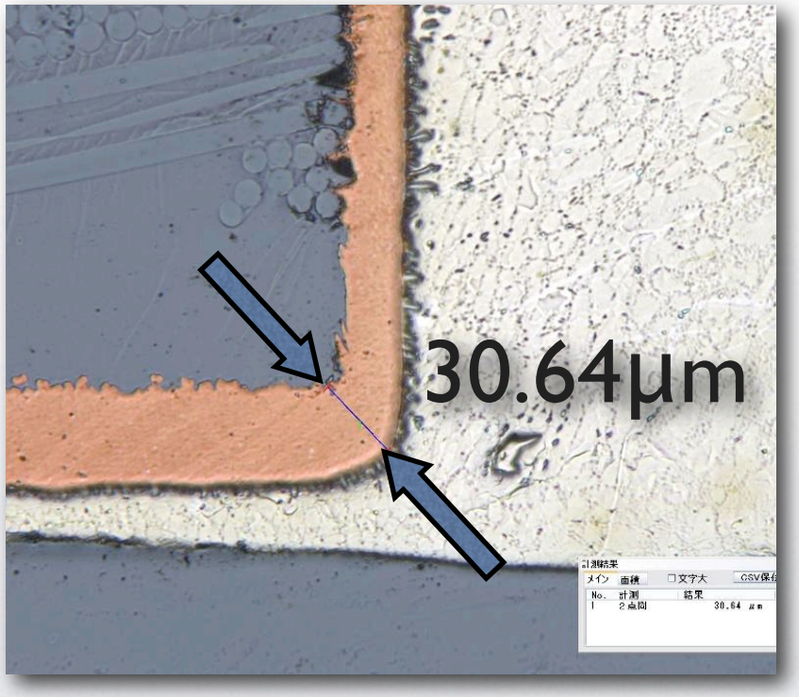
Drop Test Results

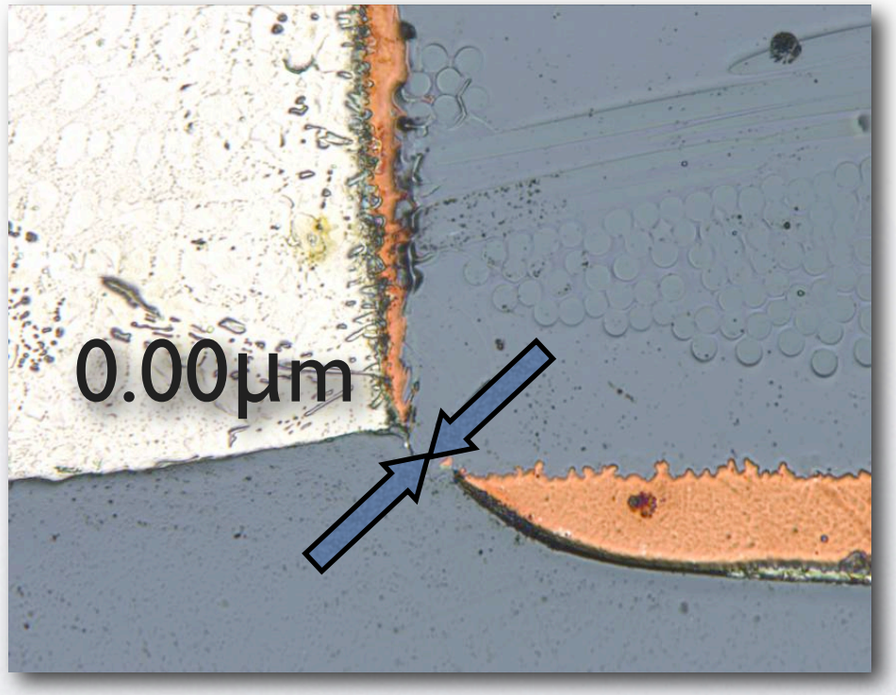


A Drop Test in DoD

Copper Dissolution

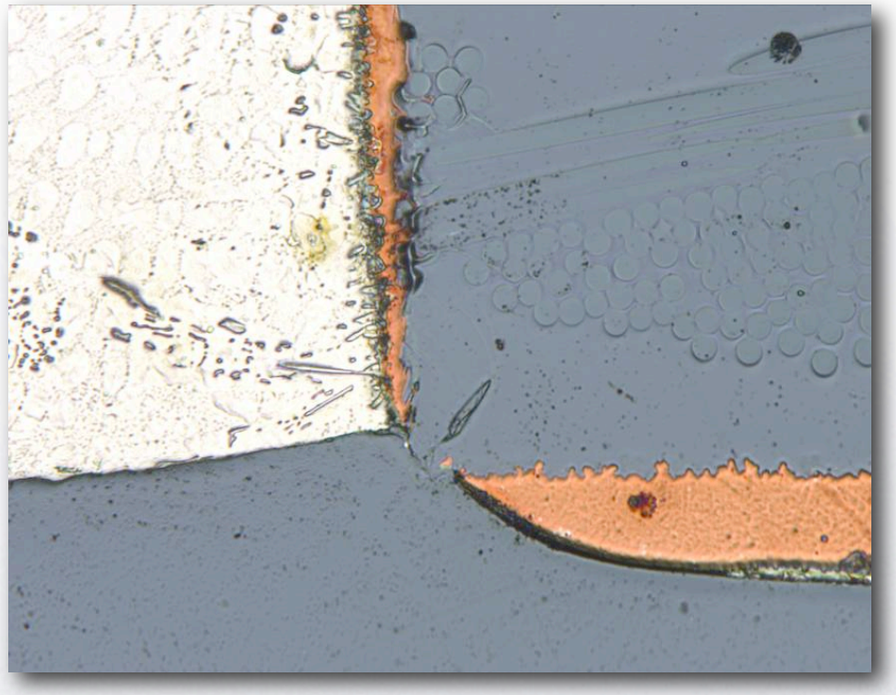
- Erosion of copper as a result of exposure to molten solder





Copper Dissolution

- Inherent with all soldering processes
- Exacerbated with Pb-free and higher processing temperatures



Cross Contamination

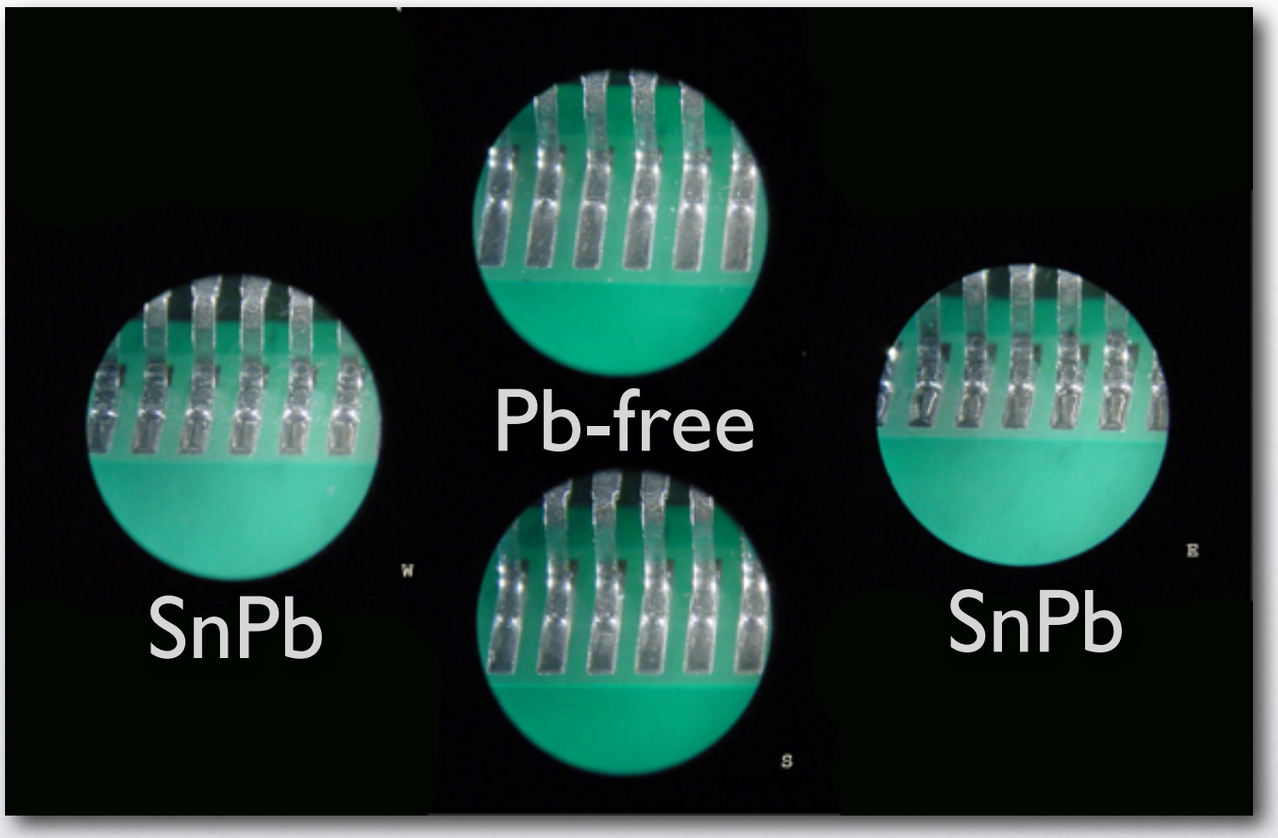
- Alloy Proliferation
- One study shows 0.5% Pb in Pb-free solder reduces reliability by 50%
- Placing a SnPb component in a Pb-free CCA could cause serious reliability issues
- Compatibility between alloys is unknown

Processing Temperatures

- Pb-free solders melting points 30-40°C higher
- Potential damage to boards and components

Other Issues

- Detection
  - Pb-free may not readily identifiable visually
  - Detection equipment expensive



Impact on Readiness

- What is the impact of Pb-free on electronics in military environments?

Conclusions

- There are very real reliability concerns with the use of Pb-free in military electronics including COTS
- There is no suitable “drop-in” replacement for SnPb yet identified
- DoD policy is yet to be defined
- Efforts are underway to find answers
- The “final” answer may be years away

Additional Information

- Contact the DoD Soldering Technologies Working Group at DoD_Lead-free@navy.mil for additional information.
- The STWG Lead-free Community of Practice (CoP) is a corroborative on-line tool available to USCG and DoD personnel with a .mil email address.
- Access to the CoP is at https://afkm.wpafb.af.mil/ASPs/CoP/ClosedCoP.asp?Filter=MC-LG-01-81