

LEAD-FREE SOLDERS

for Architectural Metals

JOHNSON'S PORTION OF
A DISCUSSION ABOUT THE ROLE OF
SOLDERS, FLUXES, TECHNIQUE
AND JOINT DESIGN

Presented by F. Larry LePrevost, EVP
Johnson Mfg. Co.
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Revere Copper
at RCI in Orlando, FL on March 3, 2007

LEAD-FREE SOLDERS

- Lead-free solders are comprised mostly of Tin, chemical symbol (Sn) from the Latin root word Stannum, plus elements like Antimony (Sb), Silver (Ag) Copper (Cu), Nickel (Ni) and others.
- Lead-free solders that contain less than 0.2% Lead (Pb) from the root word Plumbum, meet US specifications for Lead-free solders, but only 0.1% is allowed according to Europe's RoHS Directive, which was effective July 1, 2006.
- Johnson's Lead-free solders typically contain less than 0.05% Lead (Pb) by actual analysis.

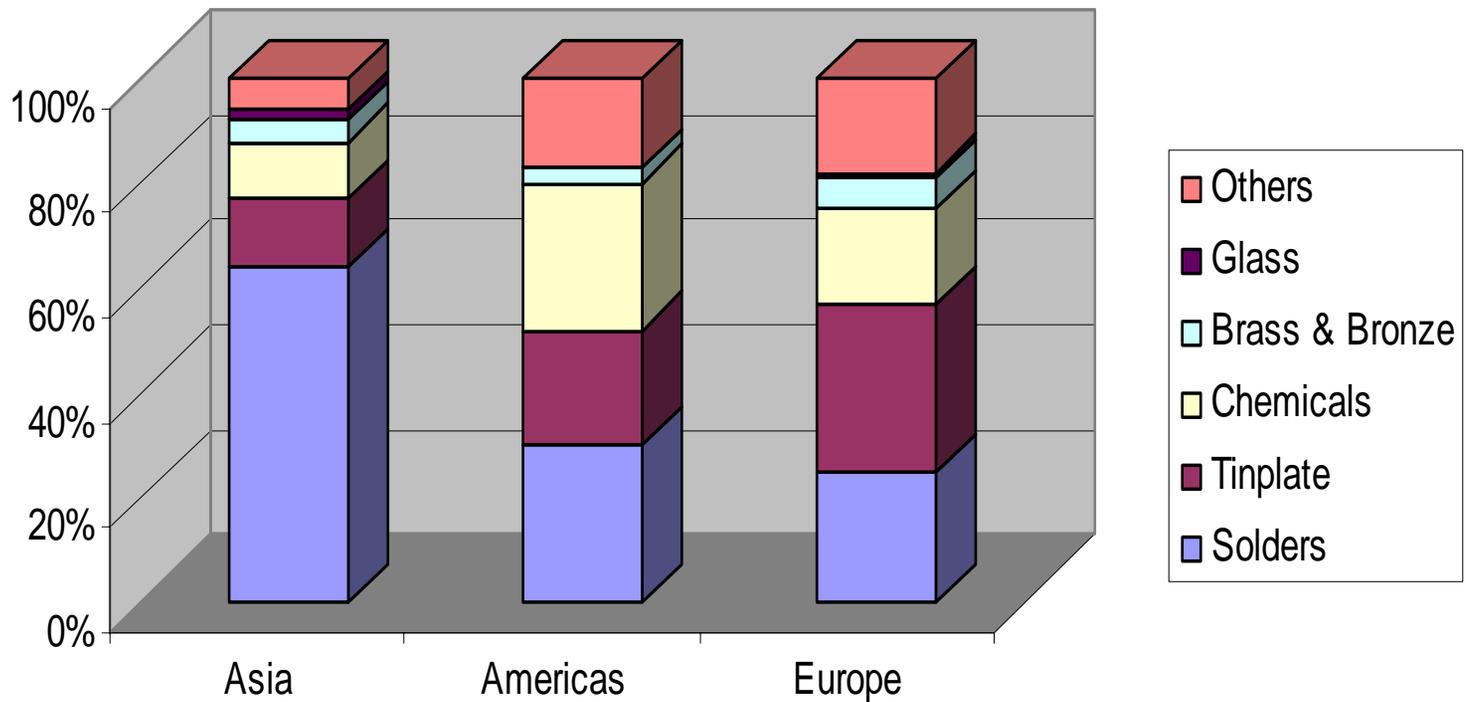
HOW LEAD-FREE GOT ITS START

- The Clean Water Act of 1986 directed EPA to enforce stricter lead standards (0.2% max) for solders used for potable (drinking) water supplies.
- OSHA followed shortly after with higher standards for worker health and safety. This evidenced the need for lead-free solders in many industries. Automakers began using lead-free body solders made of tin, copper and zinc, the food service industry uses only tin-silver alloys and now the electronics group is beginning to use SAC alloys (Sn/Ag/Cu) Tin, Silver and Copper.
- To fill an ever increasing need for lead-free solders, manufacturers have developed, patented and licensed many new alloys in recent years.

TIN USE BY REGION

Information obtained from ITRI report, Feb-2007

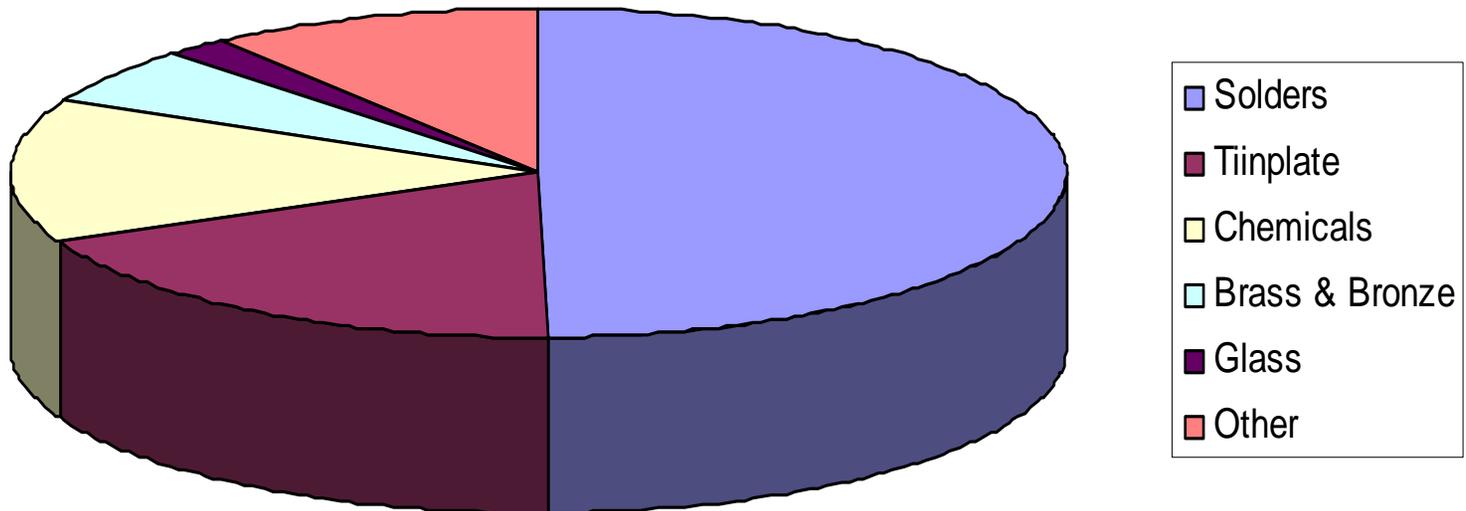
REGIONAL END USE % SHARE



TIN USE BY APPLICATION

Information obtained from ITRI report, Feb-2007

TIN - WORLD USE BY APPLICATION - 2005



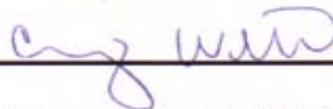
JOHNSON'S #497 LEAD-FREE TYPICAL ANALYSIS

CERTIFICATE OF ANALYSIS

Johnson Manufacturing Company
Princeton Iowa

Alloy: #497 Analysis Date: 1/10/2007
Melt: 26793

Element	% by Weight
Sn	97.31527
Sb	1.91997
Ag	0.33773
Pb	0.02460
As	0.00206
Bi	0.00429
Cd	0.00012
In	0.00396
Cu	0.38764
Al	0.00042
Fe	0.00062
Ni	0.00044
Zn	0.00022



Craig Willi--Johnson Manufacturing Company

JOHNSON'S SPECTRO LAB SPARK ANALYZER



SOME FACTS ABOUT TIN

- Tin is the “Magic Ingredient” in all solders that dissolves other metals to create a metallurgical bond at the interface. Repeat!
- Tin is shiny, strong and ductile, and it is 36% lighter than Lead, so you get more feet per Lb.
- Tin-based solders have a higher surface tension and steeper wetting angles than tin-lead solders.
- Tin costs nearly seven times as much as Lead, based on current metal markets.

JOHNSON'S VACUUM CAST 99.9% + PURE TIN (Sn)



EVERY LOT NUMBER IS ISO TRACEABLE



SURFACE TENSION

Lead-free solder (on left) has higher surface tension than 50/50 tin-lead solder (on right).

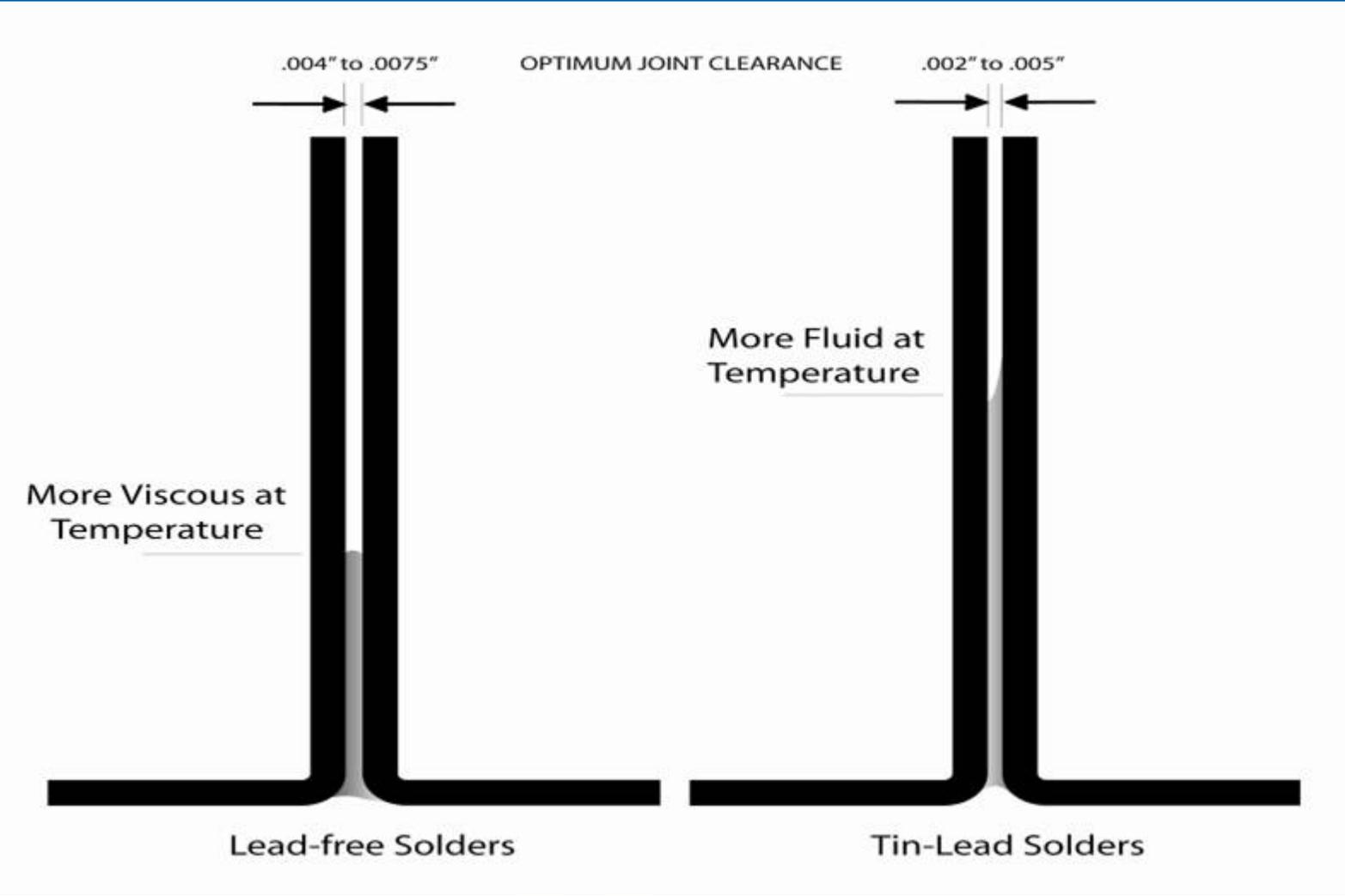


WETTING ANGLE

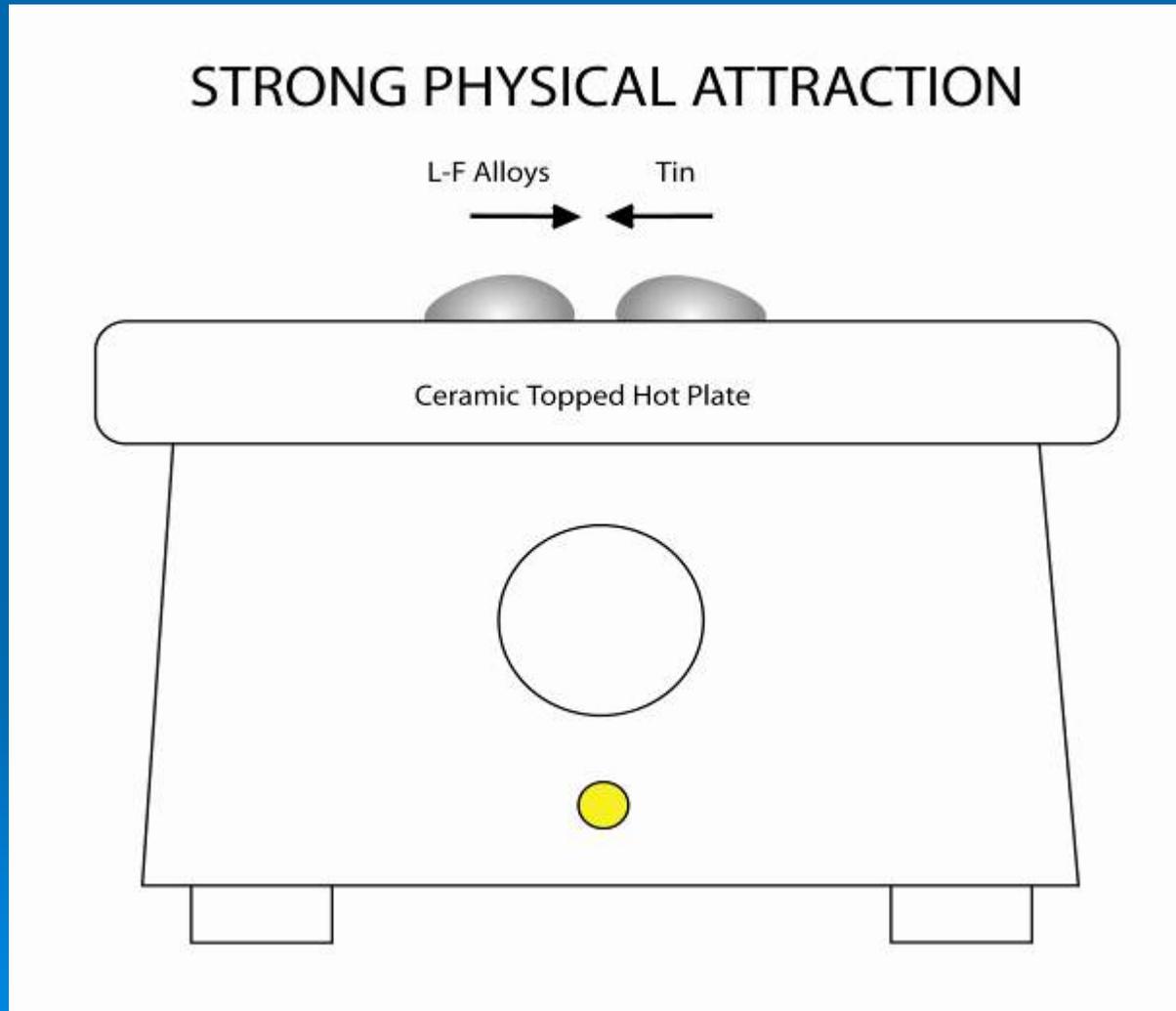
Lead-free solders have a higher radius than 50/50, which similarly effects wetting angle.



CAPILLARY RISE USING A LIQUID FLUX



METALLURGICAL ATTRACTION



WHY USE PURE TIN PASTE?

- Molten tin acts like a magnet to pull Lead-free solders deep inside the seams.
- Lead-free solders being mostly tin, are highly attracted to freshly tinned, or molten tin surfaces.
- Pretinning, or tinning on an “in situ basis” assists capillary and wetting forces by reducing the high surface tension that is inherent in all Lead-free solders, as well as coated metals like Zinc-Tin (Zn/Sn) coatings on both copper and stainless.

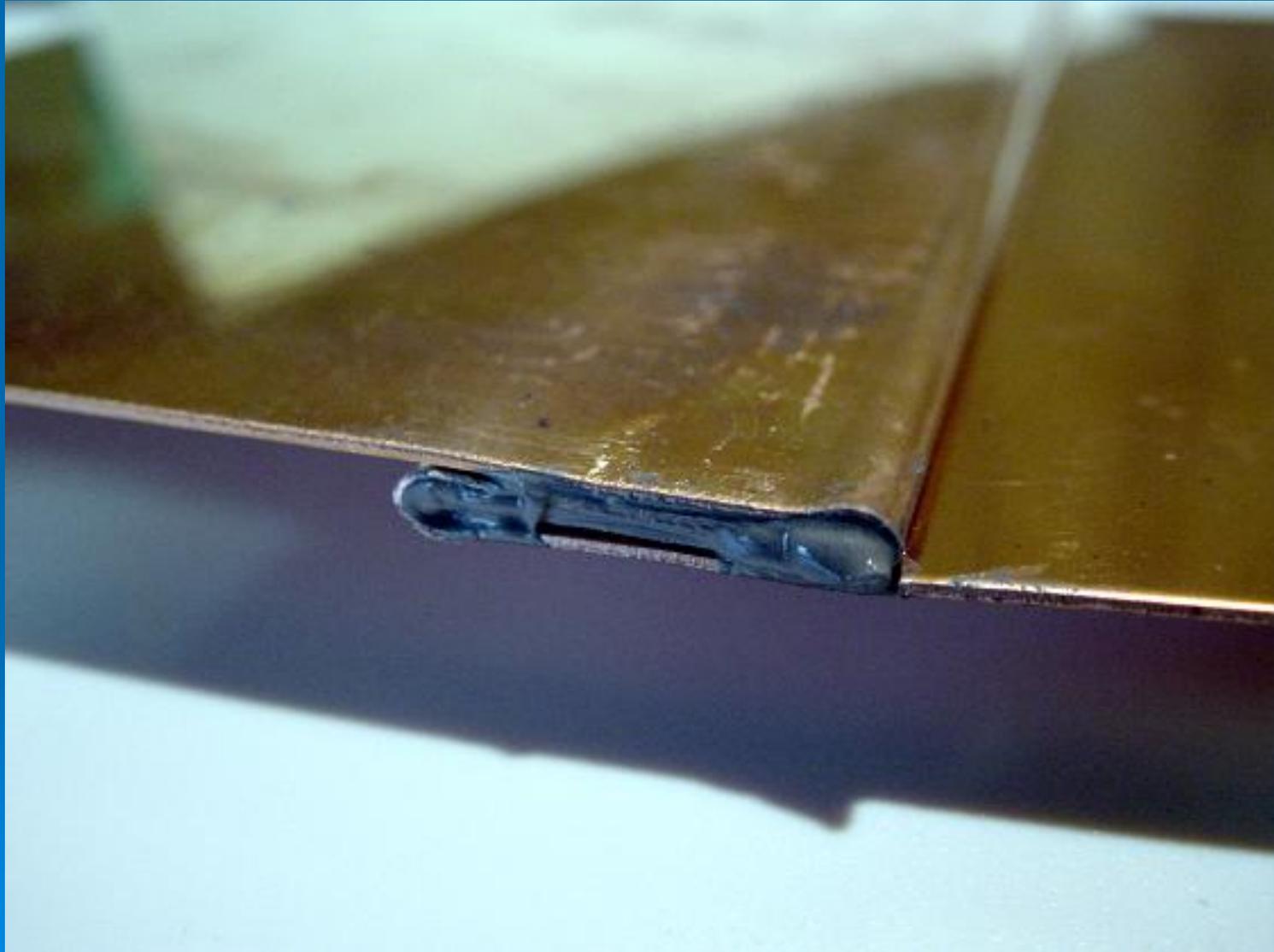
APPLYING PURE TIN PASTE



HAMMERED DOWN SEAM



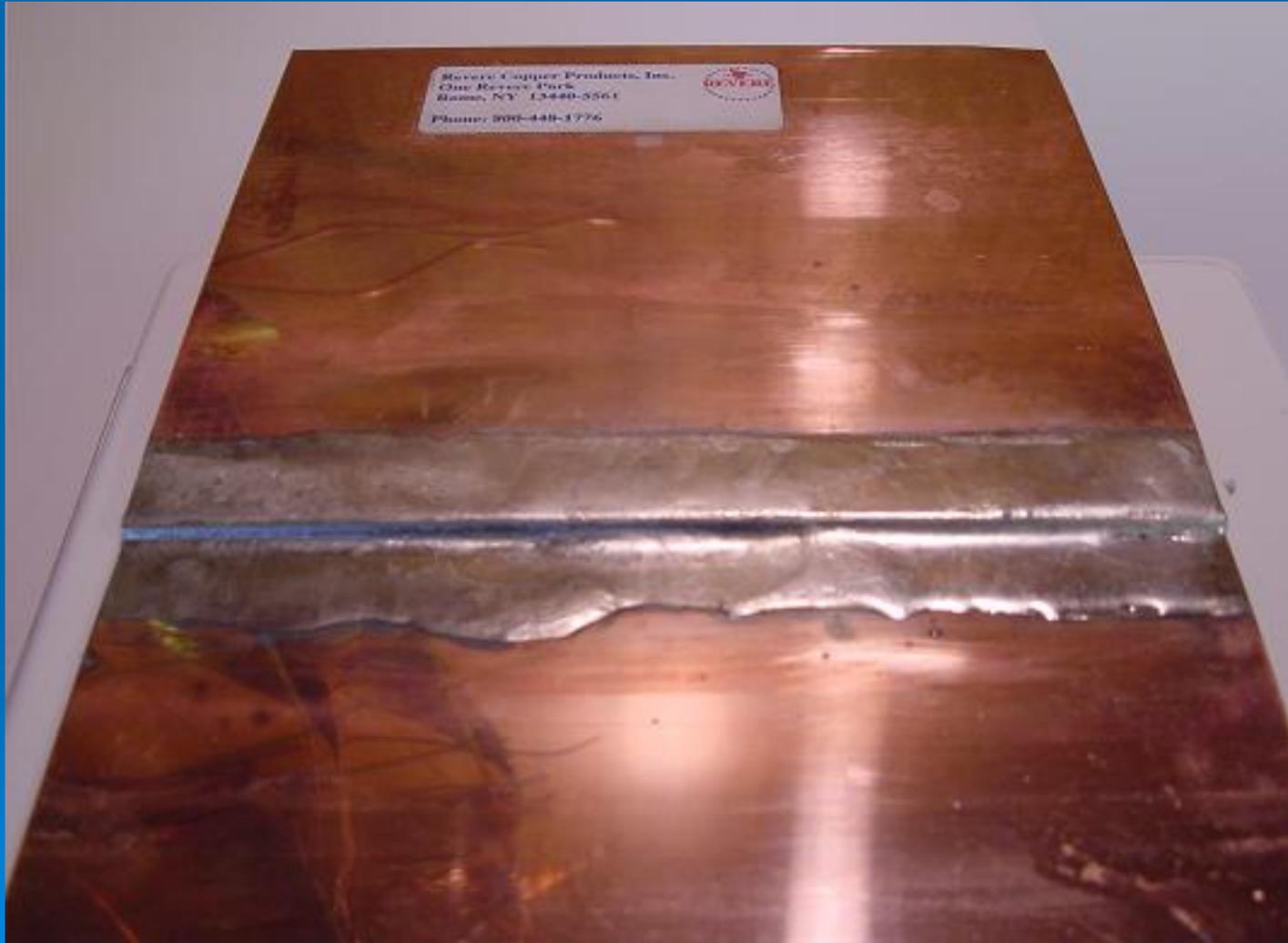
SEAM WITH PURE TIN PASTE



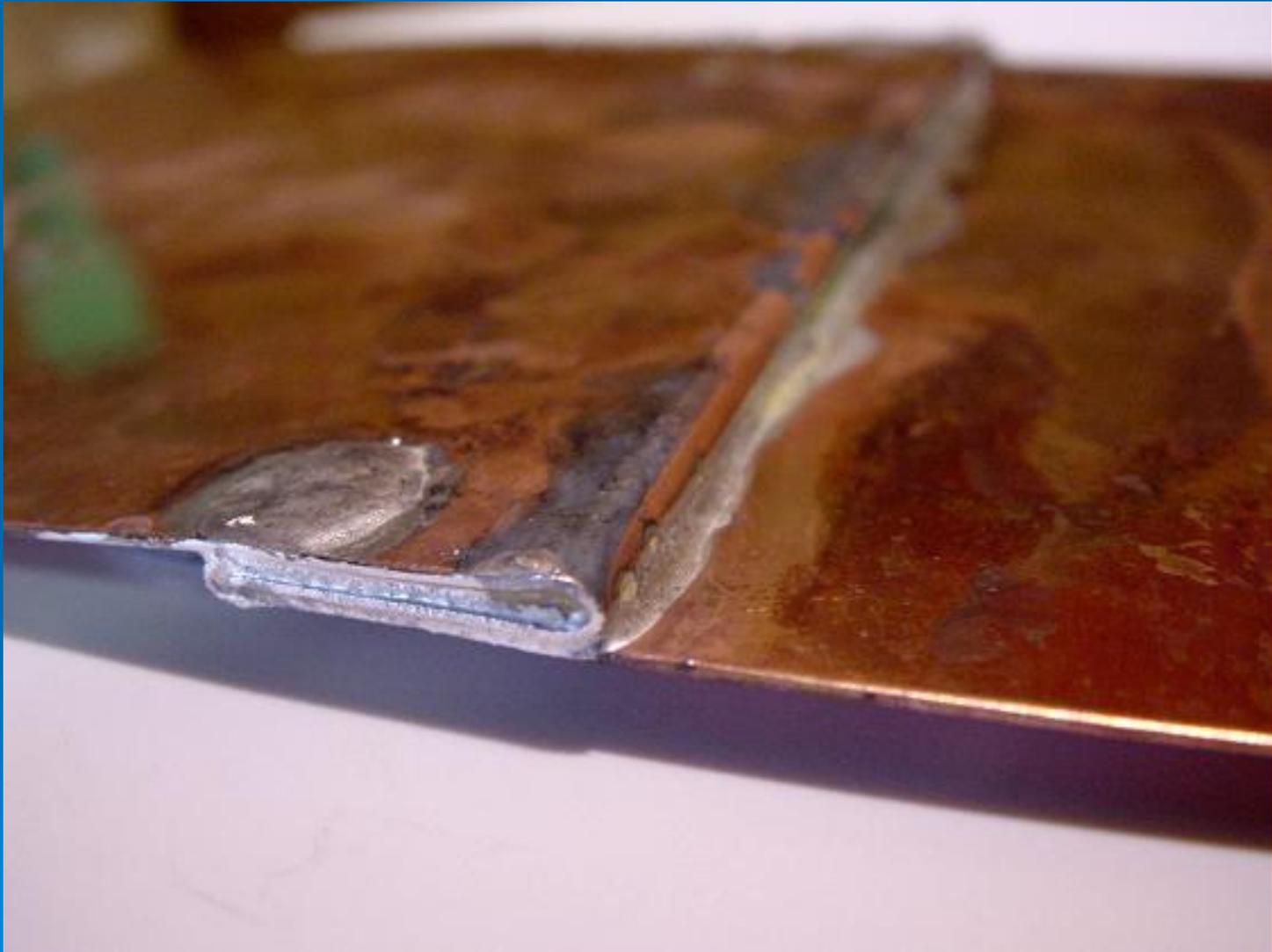
BRUSH PURE TIN PASTE ON TOP



SOLDERED WITH LEAD-FREE



LEAD-FREE PULLED THROUGH



LEAD-FREE FROM UNDERSIDE



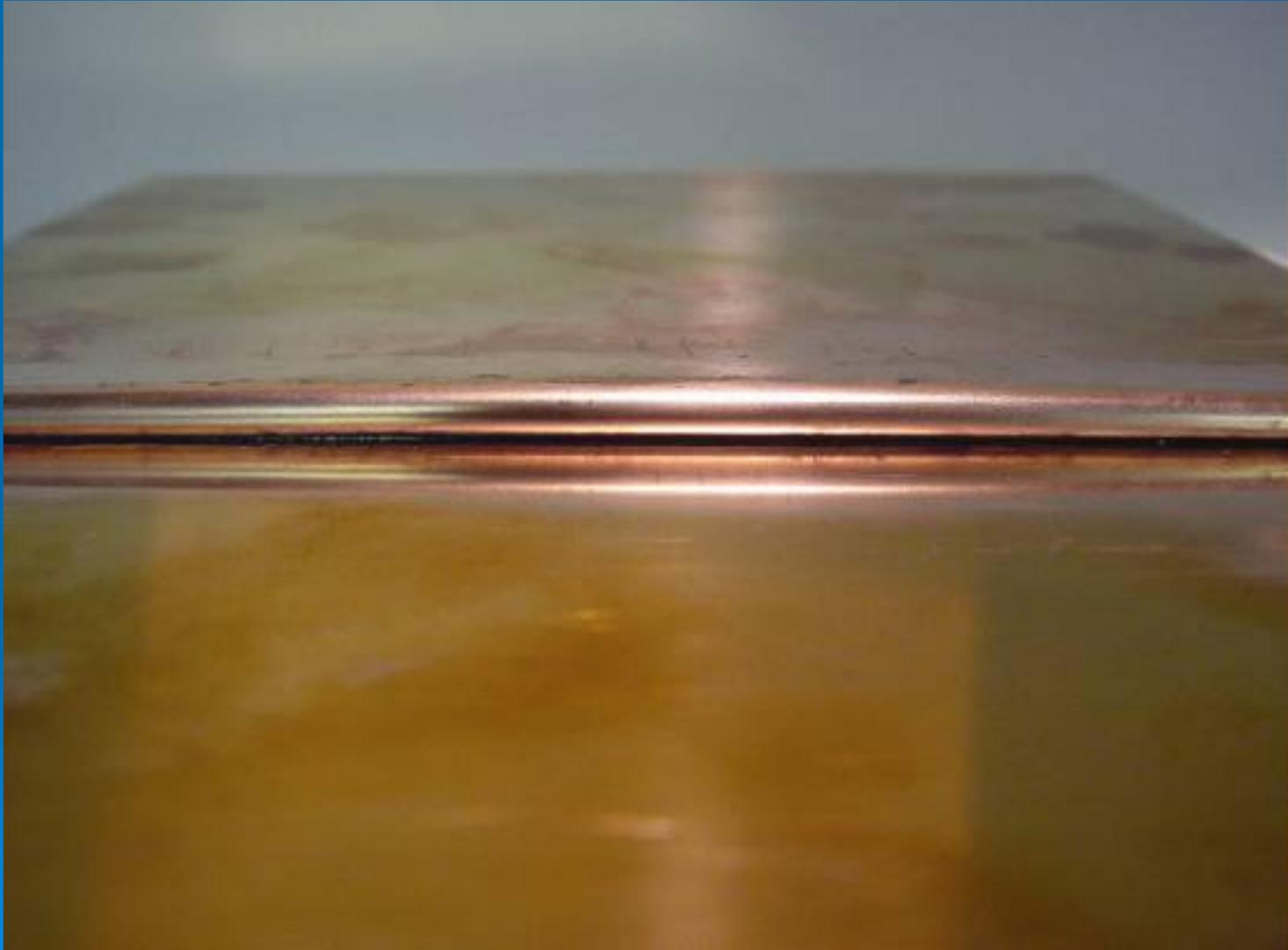
LIQUID FLUX APPLIED



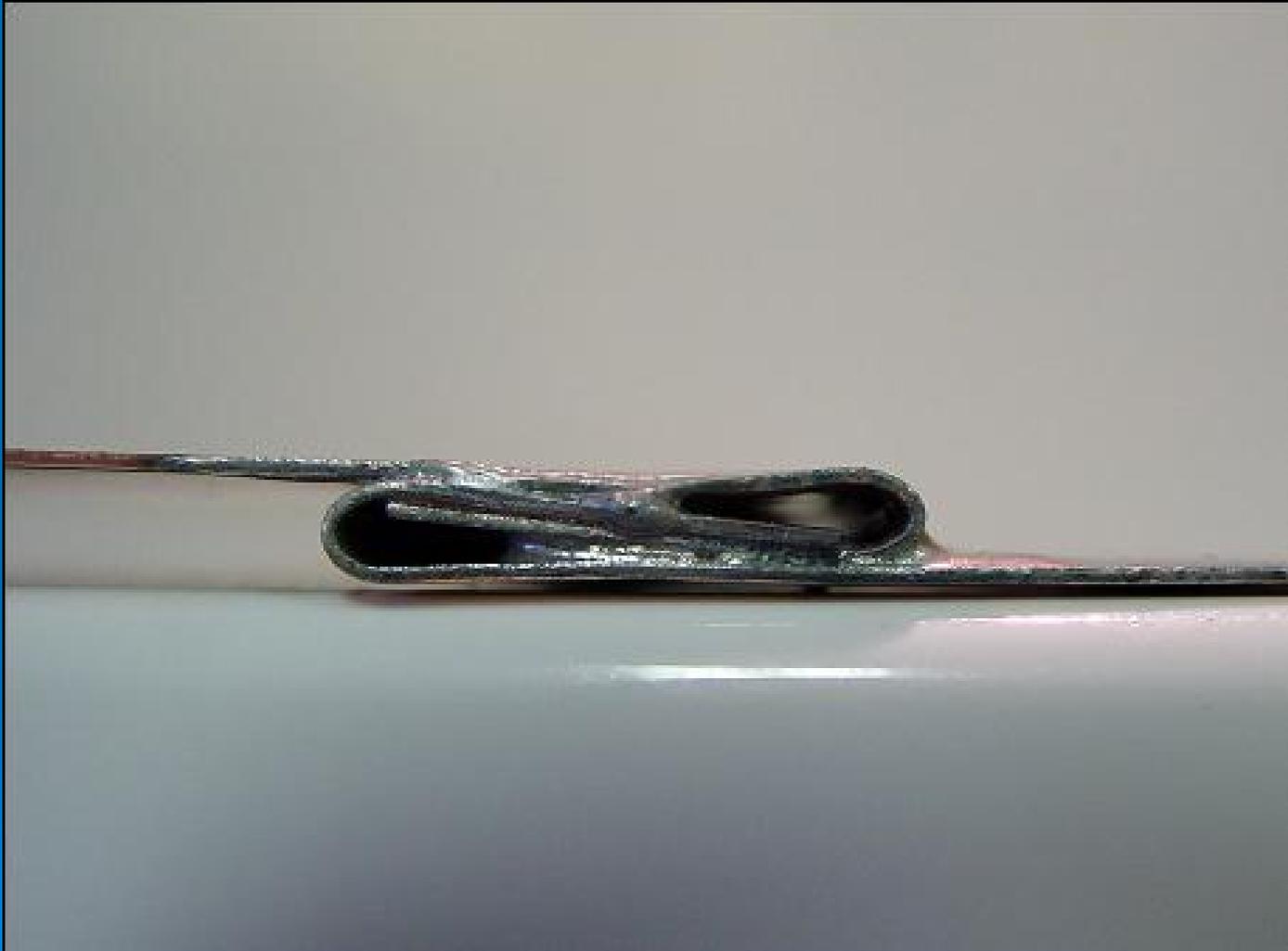
50/50 SEAM CLOSE UP



50/50 DID NOT FILL SEAM



THIS SEAM OPEN USING 50/50



SOLDERING TESTS SHOW

- Lead-free solders are not as fluid at liquidus temperature as 50/50 Sn/Pb, but when applied properly they can fill a seam as well, or better.
- Test panels were soldered nearly identically and while Lead-free filled the seam, the 50/50 did not!
- Based on current metal markets, Lead-free Solder and Tin Paste combination costs approx. 3.5 times more than 50/50 and a liquid flux.

ZINC-TIN COATED COPPER



L-F PULLED INTO THE SEAM



ZINC-TIN COATED STAINLESS



L-F PULLED THROUGH SEAM



ZINC-TIN COATED STAINLESS PROJECT IN COLORADO



TEST PANEL PREPARATION



SOLDERING WITH LEAD-FREE



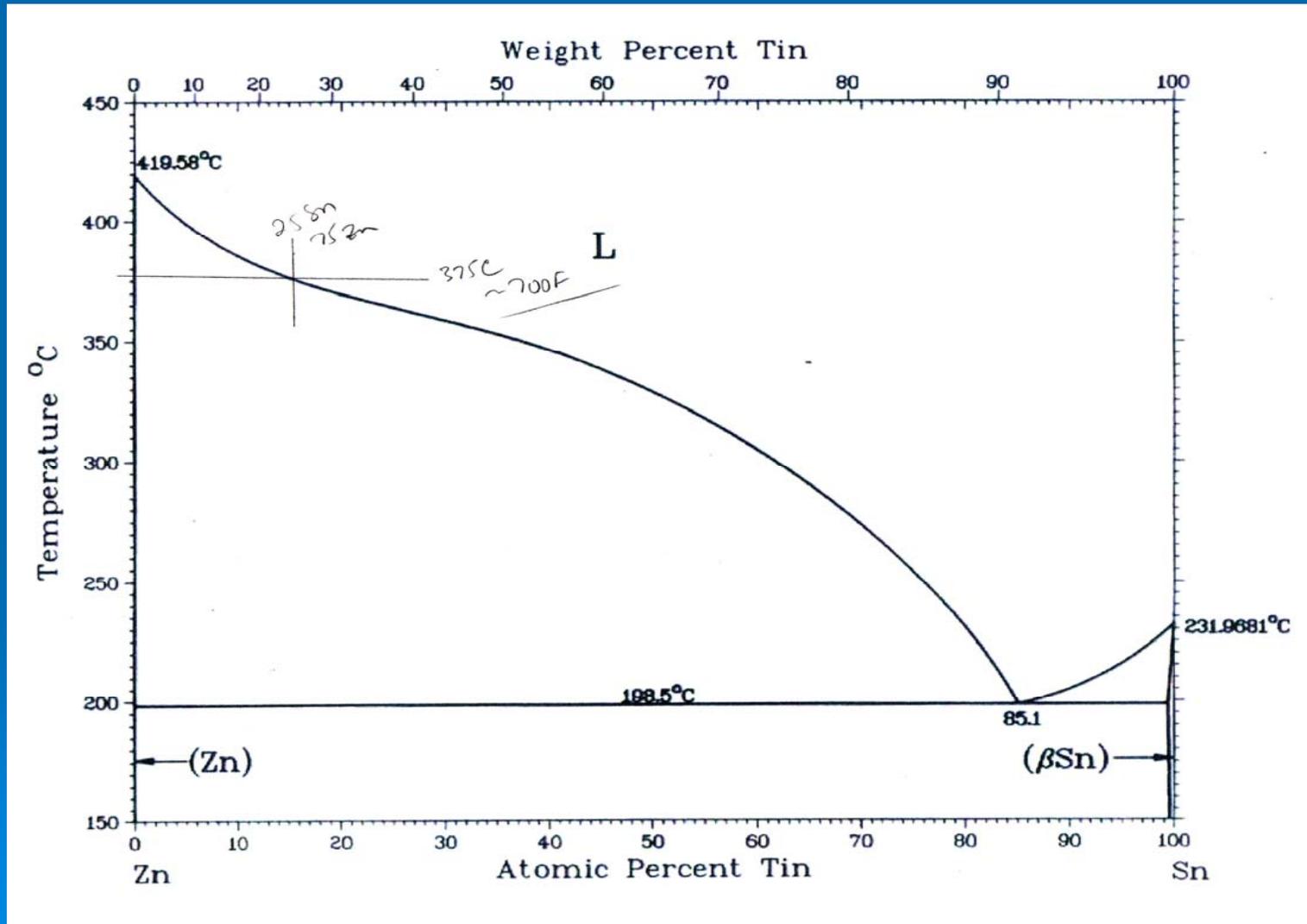
EUROPEAN STICHING TECHNIQUE



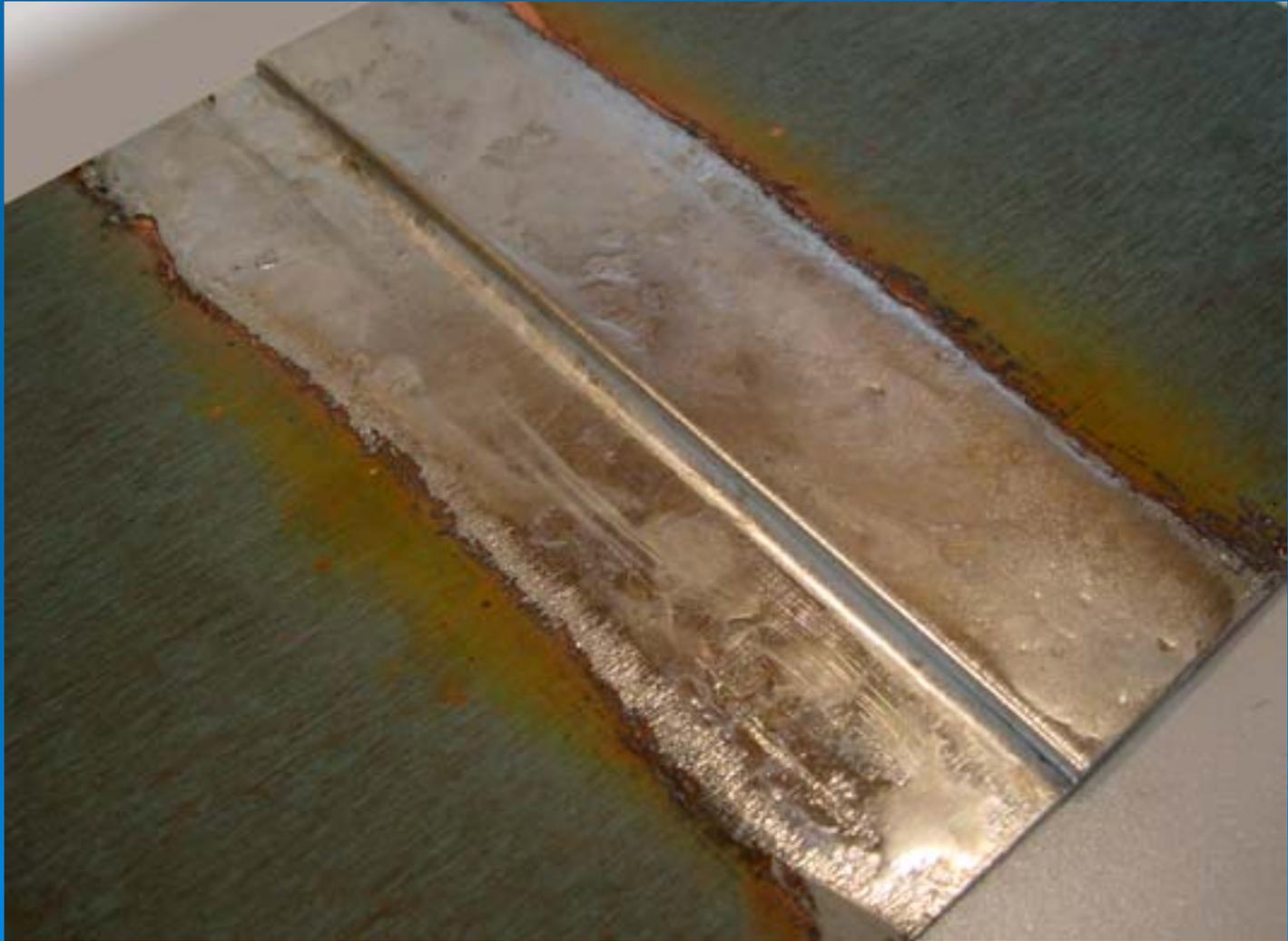
LEAD-FREE SOLDER PULLED ALL THE WAY THROUGH



ALWAYS SOLDER TO COATING



PRE-PATINATED COPPER



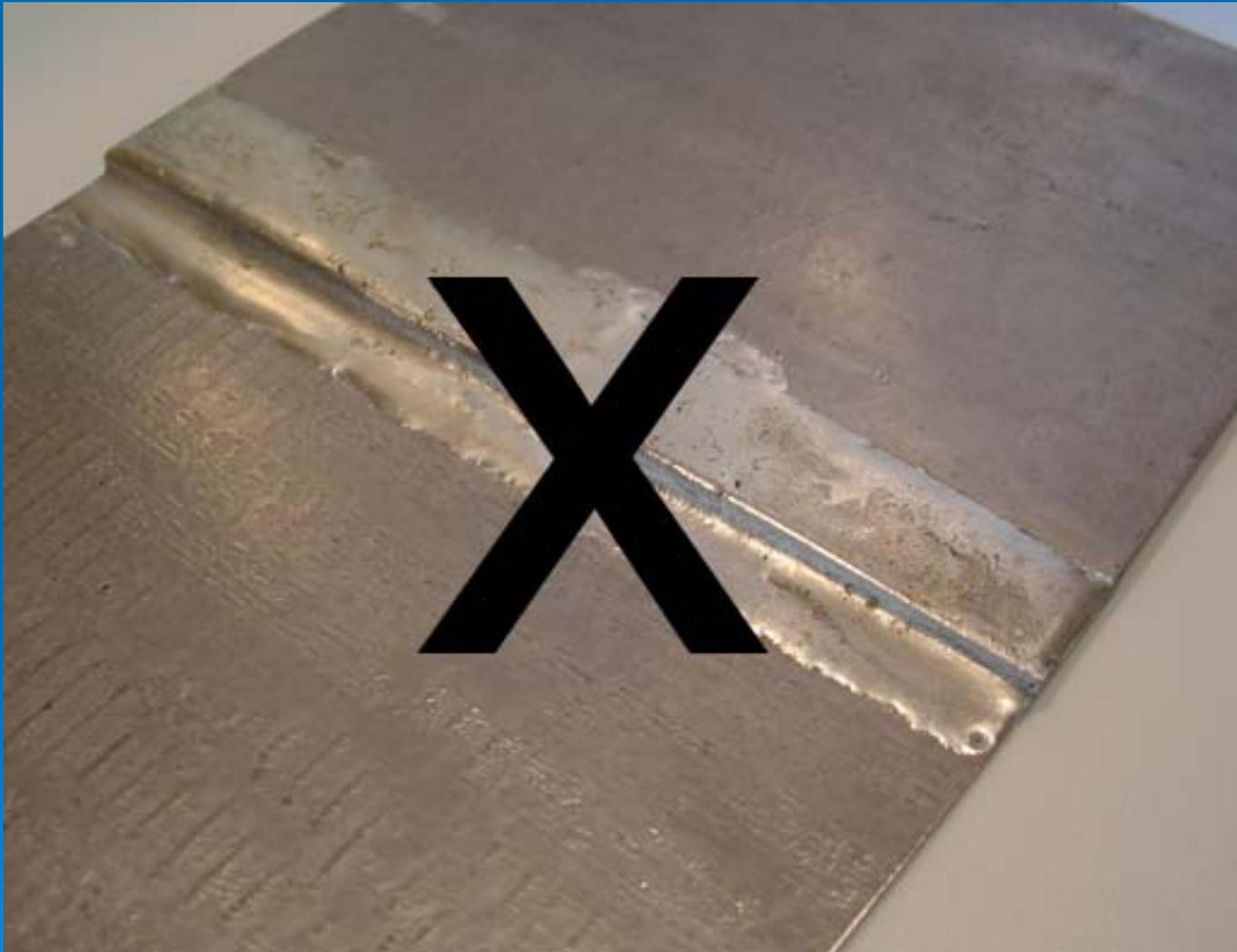
REMOVE PATINA FROM BOTH SIDES OF COPPER



VIEW FROM THE EDGE



TERNE (LEAD) COATED COPPER IS NO LONGER AVAILABLE



50/50 SOLDER FILLED SEAM



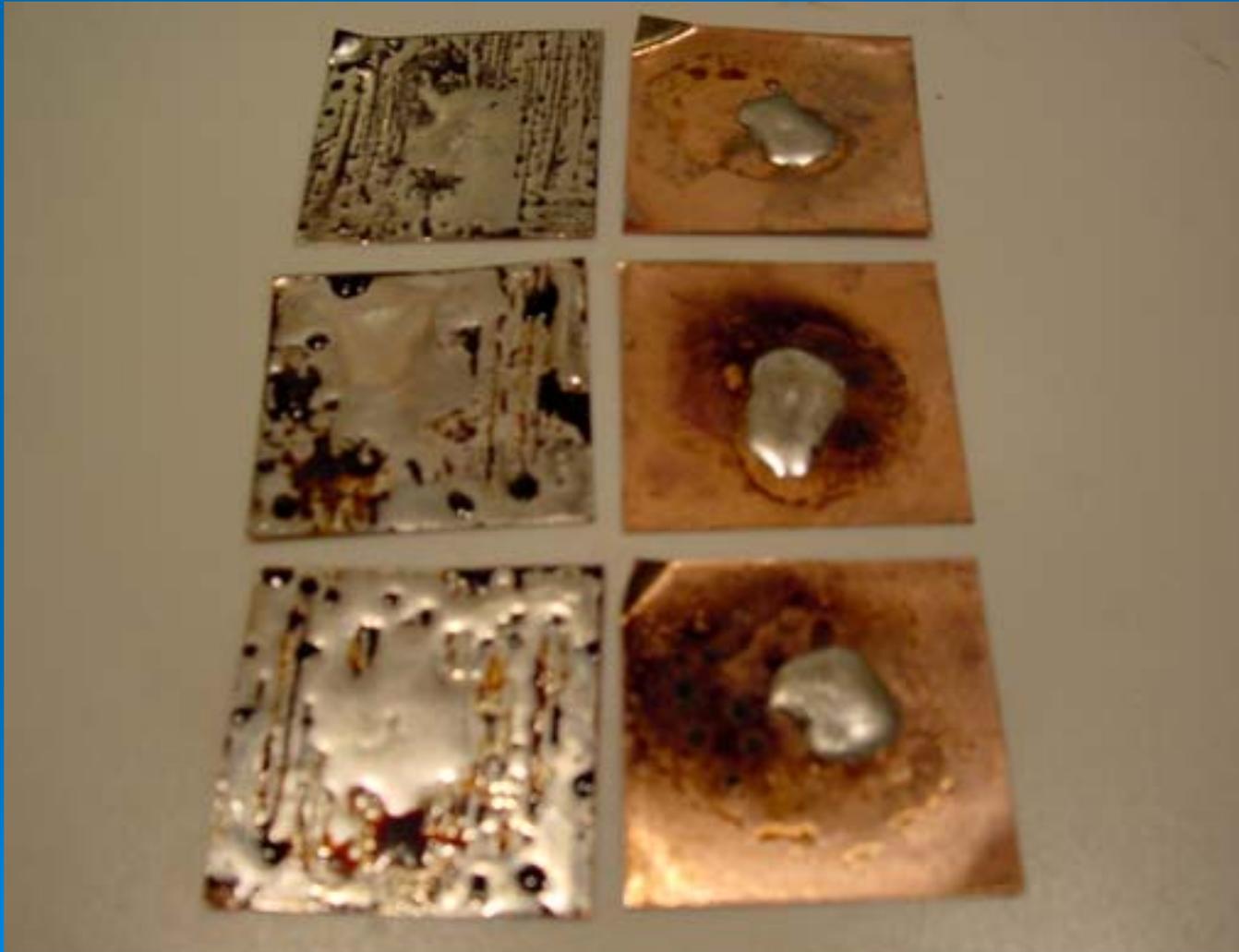
TERNE COATED COPPER EDGE



IN SITU TINNING

- Considering Tin is the “magic ingredient,” why not apply Tin Paste inside the seam where it is the most cost effective?
- In situ tinning, on-the-job attracts Lead-free solders with equal, or greater force than if panels were pre-tinned using solder pot back at the shop.
- Applying Tin Paste inside the seam means less Lead-free solder is needed to fill them.

IN SITU TINNING VS. FLUX



EASY RESIDUE REMOVAL



COMPARE IN SITU TINNING

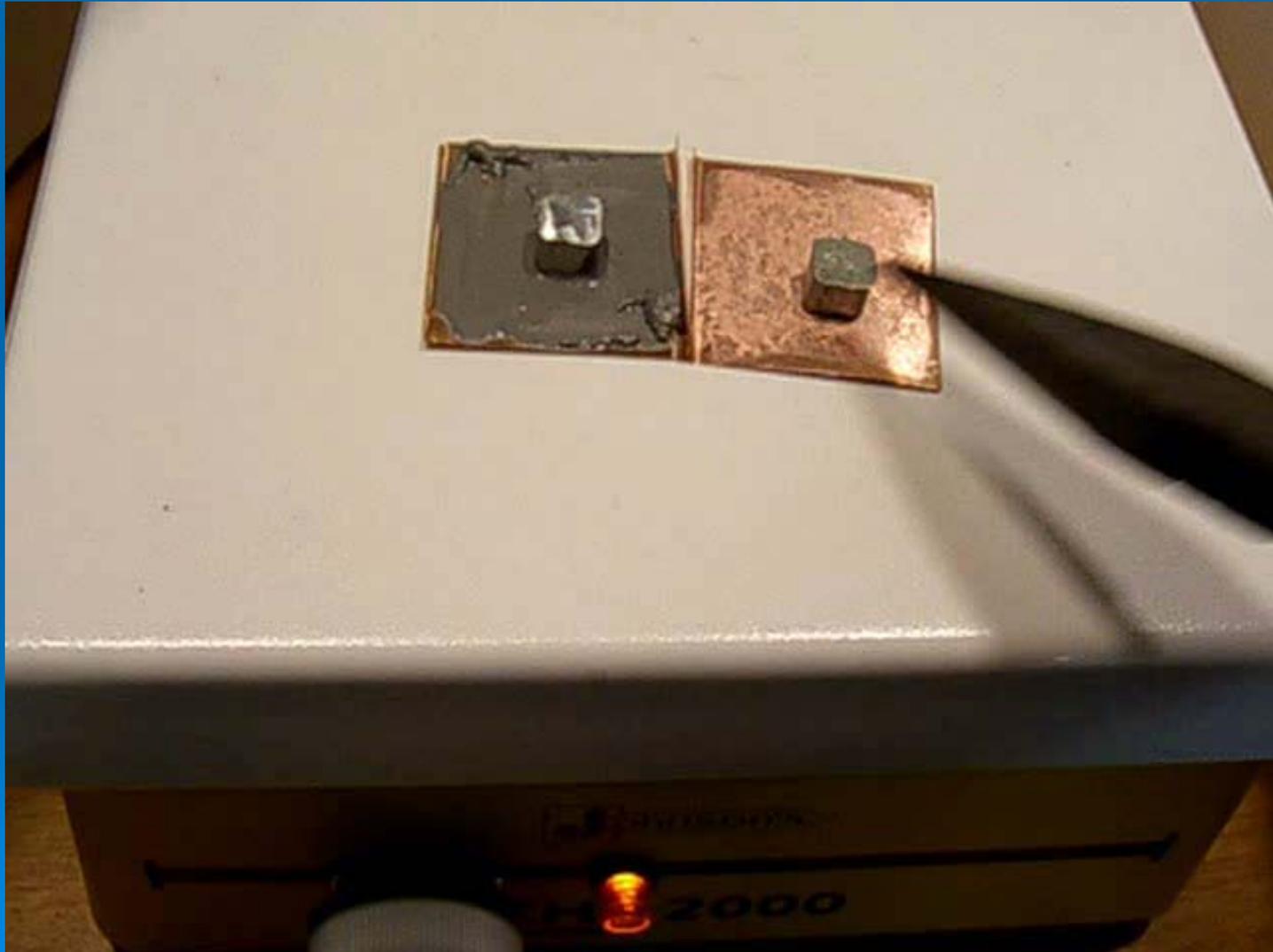


VS. STRONG ACID FLUX



IN SITU TINNING / SOLDERING

(click on picture to see movie clip)



THREE YEAR CORROSION TEST HIGH HUMIDITY CHAMBER



THREE YEAR CORROSION TEST EXPOSED TO IOWA'S WEATHER



NO PITTING CORROSION FOUND IN EITHER TEST



FACTOR IN THE HIDDEN COSTS

- Remember the “Magic Ingredient,” Tin that literally dissolves other metals? It also melts at a higher temperature (451°F) vs. 50/50 which starts to melt at 361°F (Solidus), but is not completely molten until 420°F (Liquidus), a 30°F difference.
- Combining the higher melting temperature of Tin, along with its higher content in Lead-free Solders it will tend to chew up soldering irons (coppers) about twice as fast as with 50/50 tin-lead solder, so remember this and quote accordingly.

SOLDERING COPPERS

(Forged coppers last longer!)



COPPERS MUST BE TINNED



TO PREVENT TIP EROSION

TIP EROSION



THE BOTTOM LINE.....

- There is growing interest among many in the metal roofing industry for Lead-free solders that are not only safer for workers, but better for our environment! That's because all of today's roofing metals are also Lead-free, as well!
- Lead-free solders and Pure Tin Paste can produce seams that are equal to, or better than seams made with 50/50 tin-lead solder and any liquid flux.

Now that we've mentioned all the
pros & cons, if you have any
questions, please call
Johnson Mfg. Co.

toll-free **800-747-0030**

Thanks for your interest!