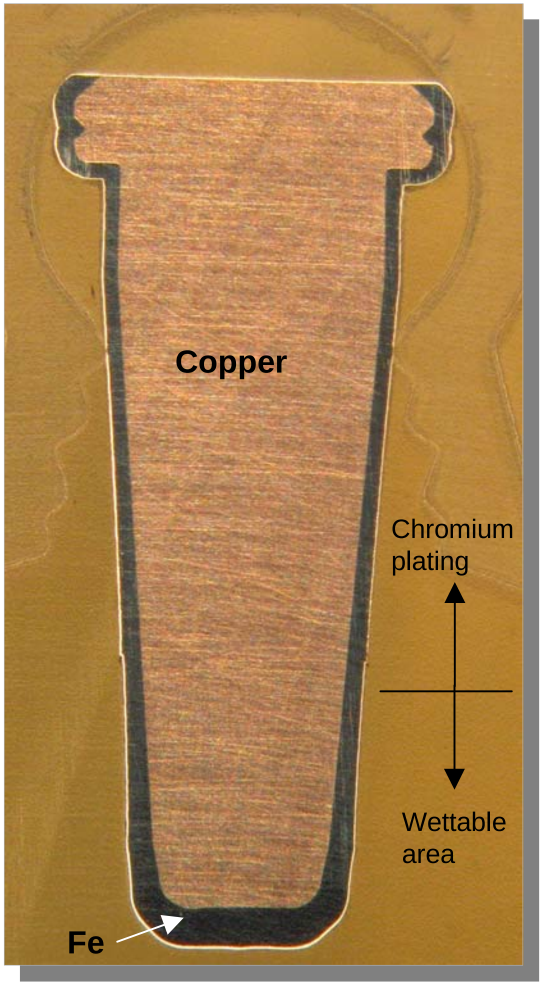
Soldering Tips & Lifetime Issues
"Coping with Lead-Free"

Why are we here?

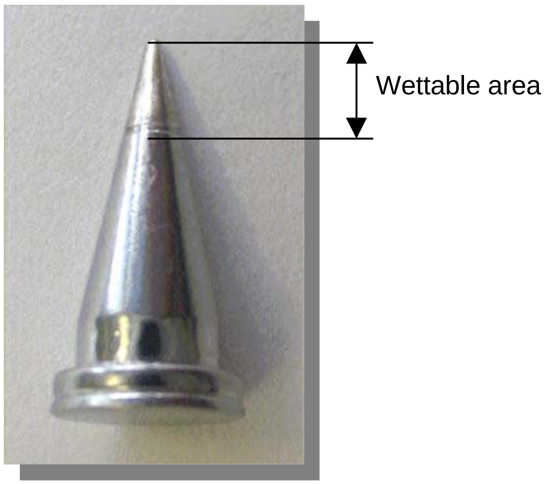
To make sales and marketing personnel more valuable to their customer by providing some basic knowledge to them about Lead-free solder and it's effect on tip life and hand soldering applications.

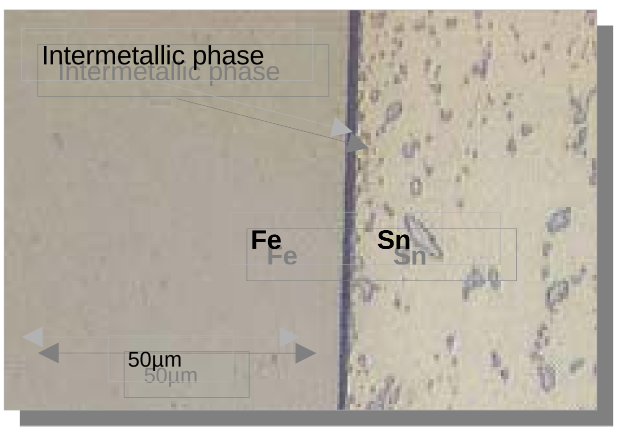
Tip Construction



Cross Section LTC tip

- Architecture of a Soldering Tip
  - **Copper Core**
    Responsible for the high heat conductivity of the soldering tip.
  - **Iron Layer**
    Responsible for high wear resistance.
  - **Chromium (Chrome) Layer**
    Responsible for confining the wettable area.
  - **Tinned Working Area**
    Responsible for the wettability of the soldering tip.
  - **Lead-Free Tinning**
    Responsible for protecting the working area of the tip when it is new.





- **Wettable Area of the Soldering Tip**
  - The wettable area is the working area and is responsible for the heat transfer.
  - Tinning produces an intermetallic bond between the Iron (Fe) layer and the solder alloy (Sn, Pb, Ag, etc.).
  - When the intermetallic bond is created, the tip is properly Tinned and remains wettable.
  - The thickness of the intermetallic layer grows with time and heat. Temperature accelerates the growth rate. This will Lead to more dissolution of the Iron, more erosion and a higher risk of oxidation.

Soldering tip defects

What does a “degraded” soldering tip look like?

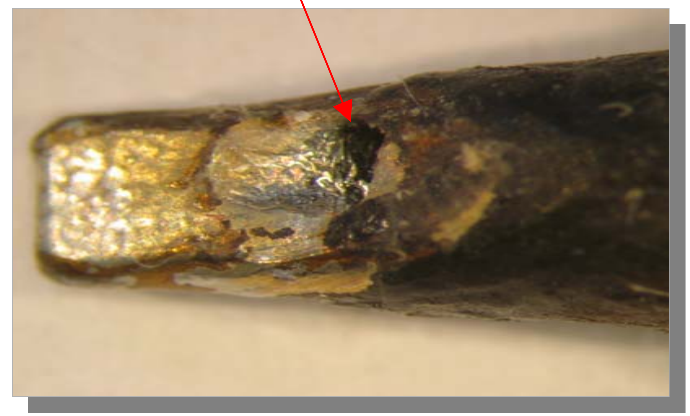
What does an “oxidized” tip look like?

• Soldering Tip Defects

- The change from a Lead bearing solder alloy to Lead Free has a significant influence on the durability of soldering tips in hand soldering applications. The higher percentage of Tin and the higher melting temperature of the Lead Free solders act more aggressively on the soldering tip and accelerate the reduction of tip life. In addition, Lead-free solders typically use a more aggressive flux formulation to compensate for the higher melting point alloys.
- **The most significant reasons for soldering tip defects**:
  - **Non-wettability of the Iron layer due to oxidation or surface contamination.**
  - **Erosion of the Iron layer due to Flux activity level, mechanical degradation, cracks / voids, etc.**
- With proper care of the soldering tip, life expectancy can be increased to a reasonable level, even when using Lead Free solders.

What does a "degraded" soldering tip look like?

Soldering process



LTC Soldering Tip "New"

LTC Soldering Tip

"Eroded"

Customer feedback

Tip Appearance

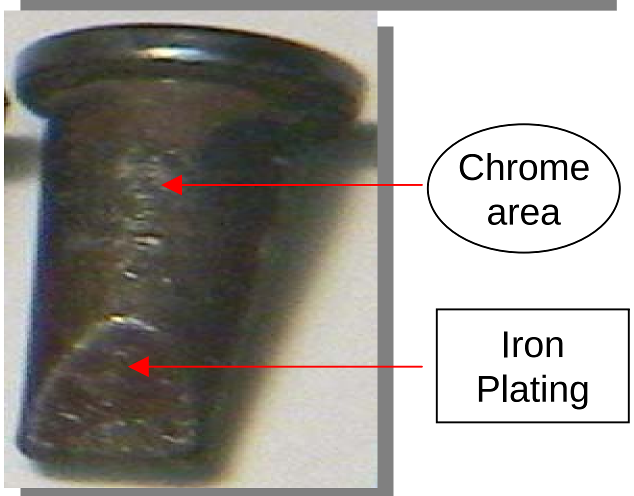
Well used LTC tip

Cross section of a degraded LTC soldering tip

- Eventually, the soldering tip is degraded by the soldering application. This means that the Iron layer that protects the Copper core is compromised. The exposed Copper erodes quickly because of the extremely high temperature and corrosion rate of Copper.
- **The durability of the soldering tip is directly relative to the Iron layer thickness.**
- As soon as the Iron layer is compromised, tip life is over and the condition will be indicated by a noticeable hole in the Copper core.
- The tip wearing process can be segregated into three levels:
  - **Corrosion caused by flux activity**
  - **Erosion of the Iron plating into the solder alloy (increased by high Sn content).**
  - **Mechanical stress caused by abrasive cleaning or "aggressive" soldering.**
- A soldering tip is a consumable component (much like the tires on a car) and a degraded tip is not an actual tip defect.

- **Surface Contamination of a Soldering Tip**
  - A soldering tip becomes contaminated and produces a non-wettable surface
  - The typical appearance of a contaminated soldering tip is shown in the these photos
  - The tips exhibit a "blackened or charred" surface finish that is very difficult to remove
  - A contaminated tip can normally be rejuvenated by a low solids, mildly active wire core solder, Tip Activator (Tinner)or Weller Polishing Bar (WPB1)
  - The heat transfer of a contaminated soldering tip is significantly reduced
  - The risk of surface contamination grows considerably when using higher tip temperatures (840°F < 30 Sec.'s)

Tip Appearance



- **Surface Contamination of a Soldering Tip**
  - A properly tinned tip will protect the wettable surface of the tip and will displace any surface contamination that may otherwise occur
  - Proper maintenance of the soldering tip will reduce the risk of surface contamination and non-wettability.
  - In many cases, surface contamination may show up as a form of "rust", which is indicative of a customer using "tap" water supplies that contain high mineral contents (iron, magnesium, etc.)
  - When "rust" is evident on the Iron plated working area, the Chromium layer above the Iron plating and the Tip Retainer, it is time to recommend using a "Distilled or Deionized" water supply
  - Tips exhibiting "rust" should be discarded due to the fact that the rust will also contaminate the soldering connection

- **Oxidation of a Soldering Tip**
  - A non-tinned soldering tip will oxidize when left exposed to air and will create a non-wettable surface
  - An oxidized tip cannot normally be reactivated by standard flux and remains non-wettable
  - The heat transfer capability of a non-wettable soldering tip is significantly lowered
  - The risk of oxidation grows as tip temperatures increase (840°F < 1min)
  - A properly tinned tip will protect the wettable surface of the tip and prevent oxidation from occurring
  - Proper maintenance of the soldering tip will reduce the risk of oxidation and non-wettability.

Tip Appearance

- **Oxidation of a Soldering Tip**
  - An oxidized soldering tip typically shows no "blackening or darkening" of the wettable area or of the Chrome area
  - The wettable area exhibits a dull grey, grainy appearance
  - The Chrome (Chromium) area may turn to a "Bronze or Blue / Bronze" which indicates that it has been heated
  - There is nothing in the metallurgical make-up of a soldering tip that will allow the metals to turn "black" (see Contaminated Soldering Tips)
  - This also holds true for the Stainless Steel on the Tip Retainer

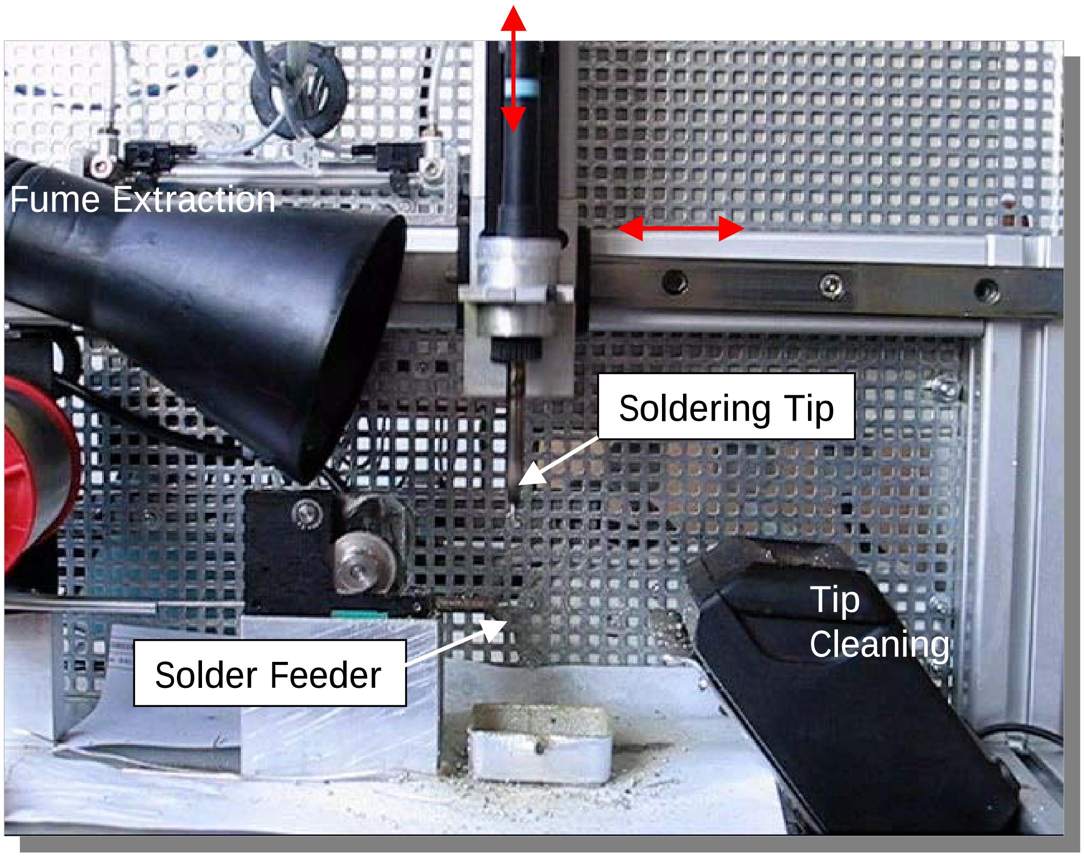
Tip Lifetime

Soldering tip after 20,000 cycles with Sn / Pb

Soldering tip after 10,000 cycles with Lead Free SAC

- **Soldering Tip Life Cycle**
  - A new tip has a Copper core covered by an Iron layer. The Iron layer protects tips against **corrosion** caused by the flux and intermetallic **migration** caused by the solder alloy
  - The high Tin content of Lead-free solder alloys begins to dissolve the Iron layer much quicker than Lead bearing solders
  - Mechanical stress / pressure also contributes to the abrasion of the Iron plated surface
  - More aggressive solders and fluxes, along with higher temperatures, increases the corrosion rate
  - After the Iron layer is penetrated, the tip is rendered useless as the Copper core will quickly dissolve

Tip Life Test Equipment



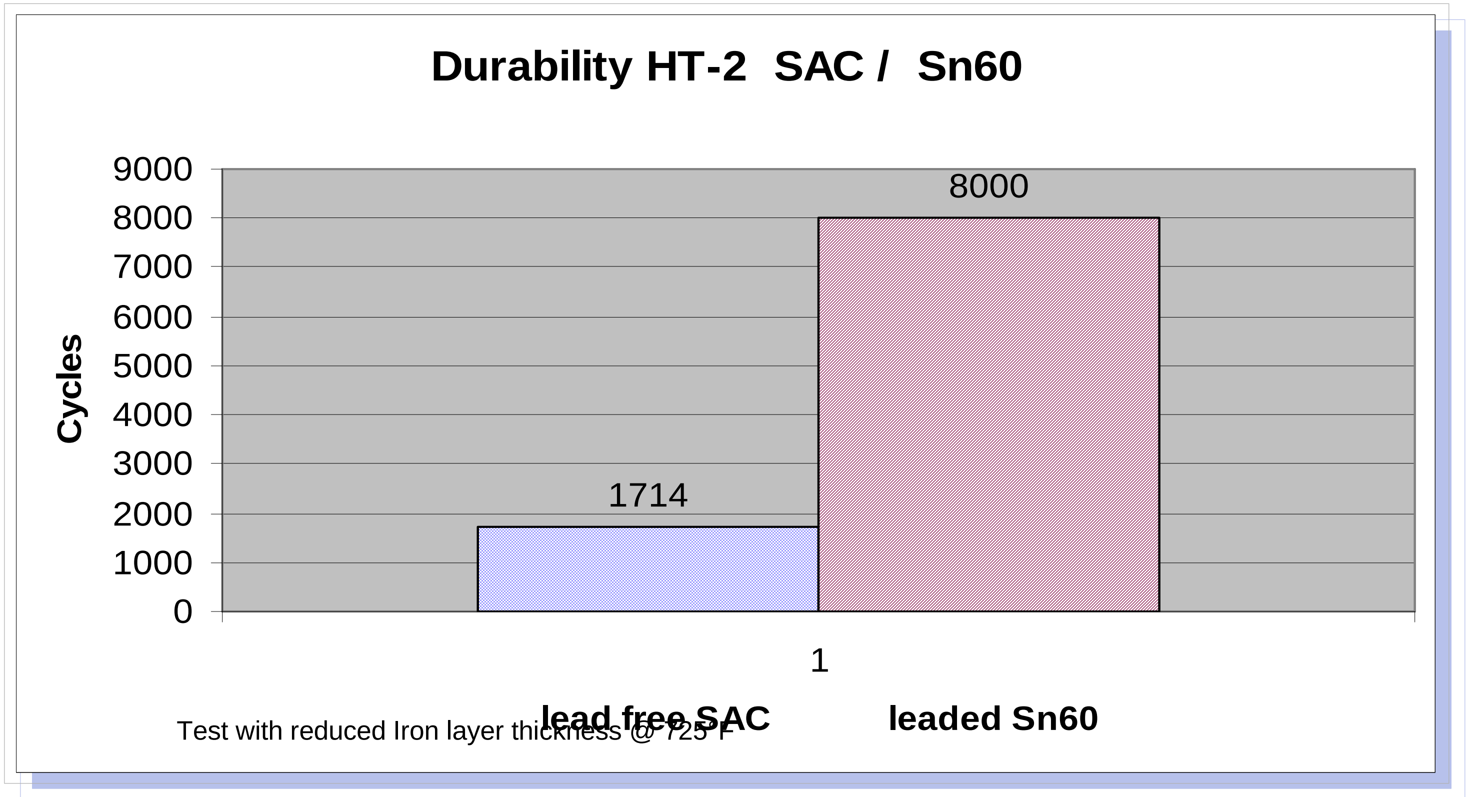
Solder Feed Test equipment assists with long term customer Alloy / Flux testing

Test equipment delivers reliable and consistent test results

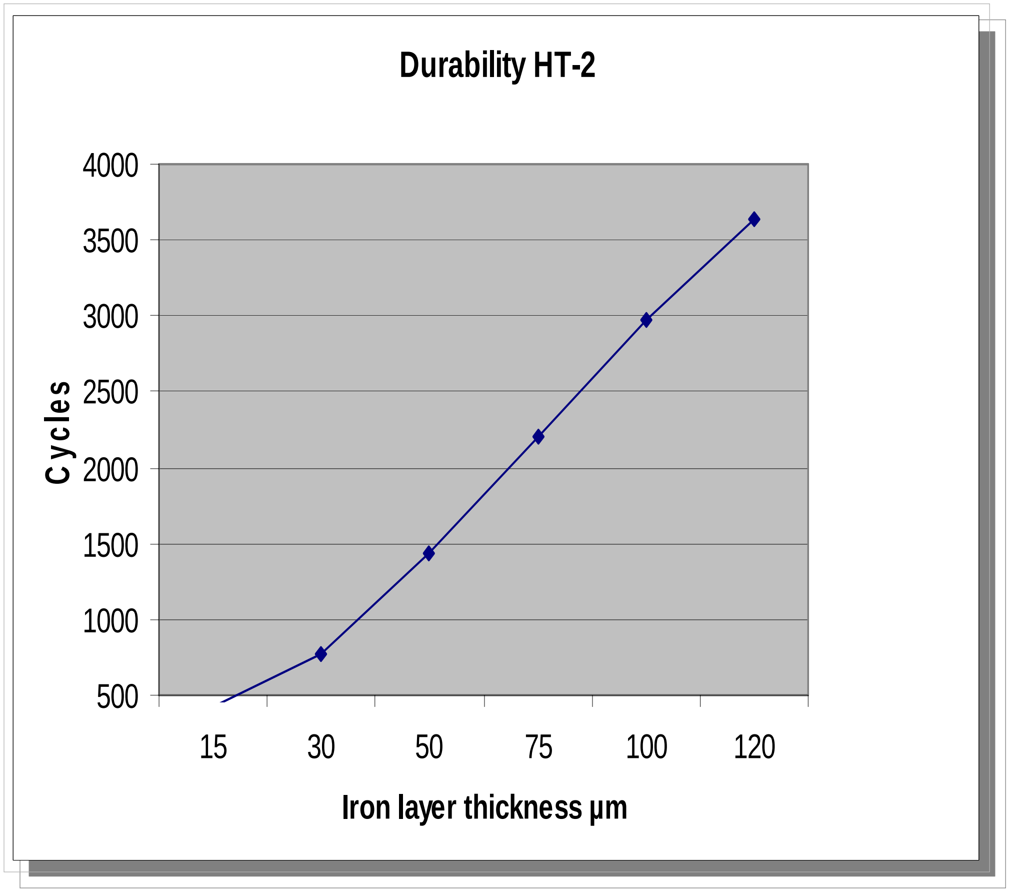
Test equipment used to determine optimum blend of Iron plating versus tip geometry.

However, the variables associated with the operator are non-existent in this type of tip life testing

- ***Tip Life Using Lead Free Solder Alloys***
  - Comparison Sn95.8Ag3.5Cu0.7 (SAC) to Sn60Pb40
  - SAC alloy erodes the Iron plating up to 4 to 5 times faster than Lead bearing solder.



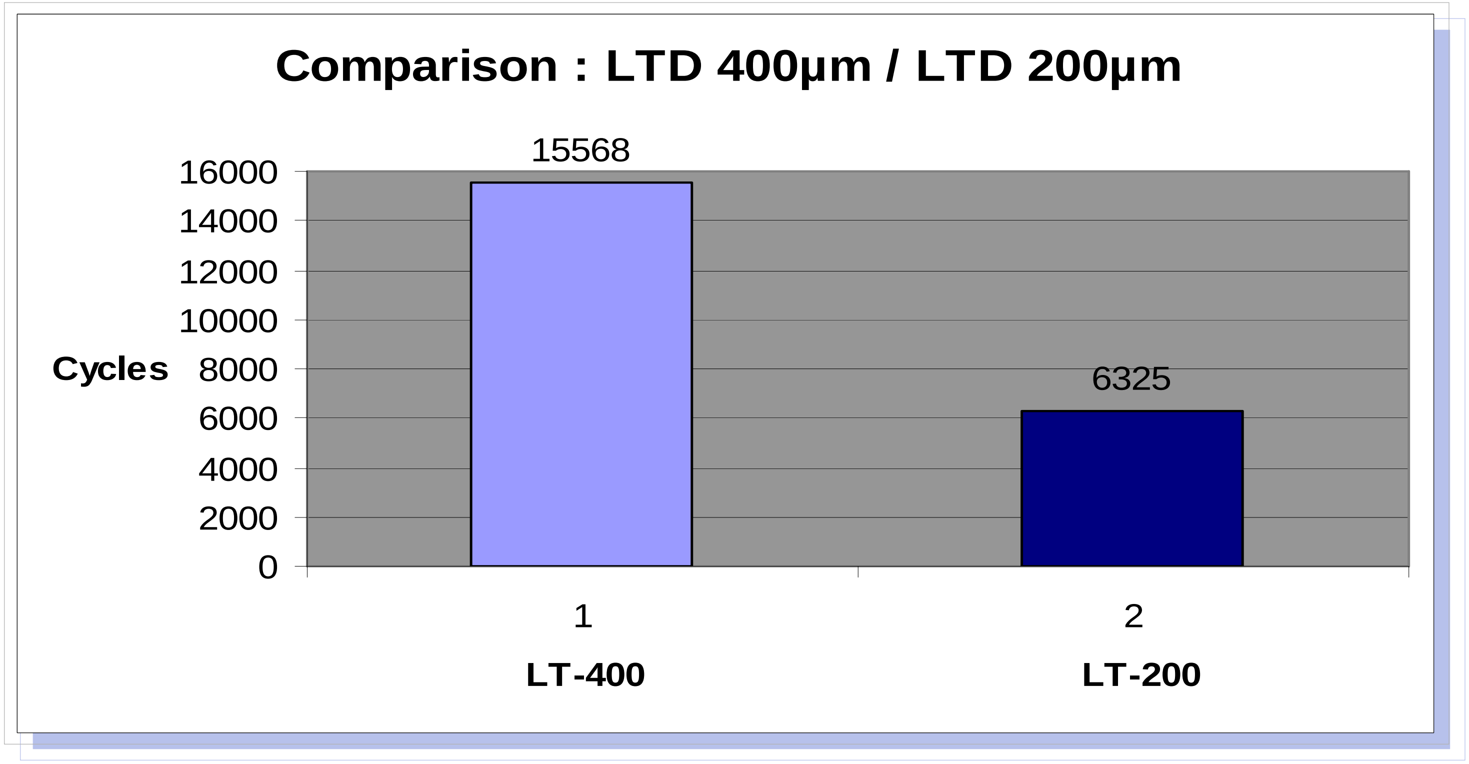
Tip Lifetime

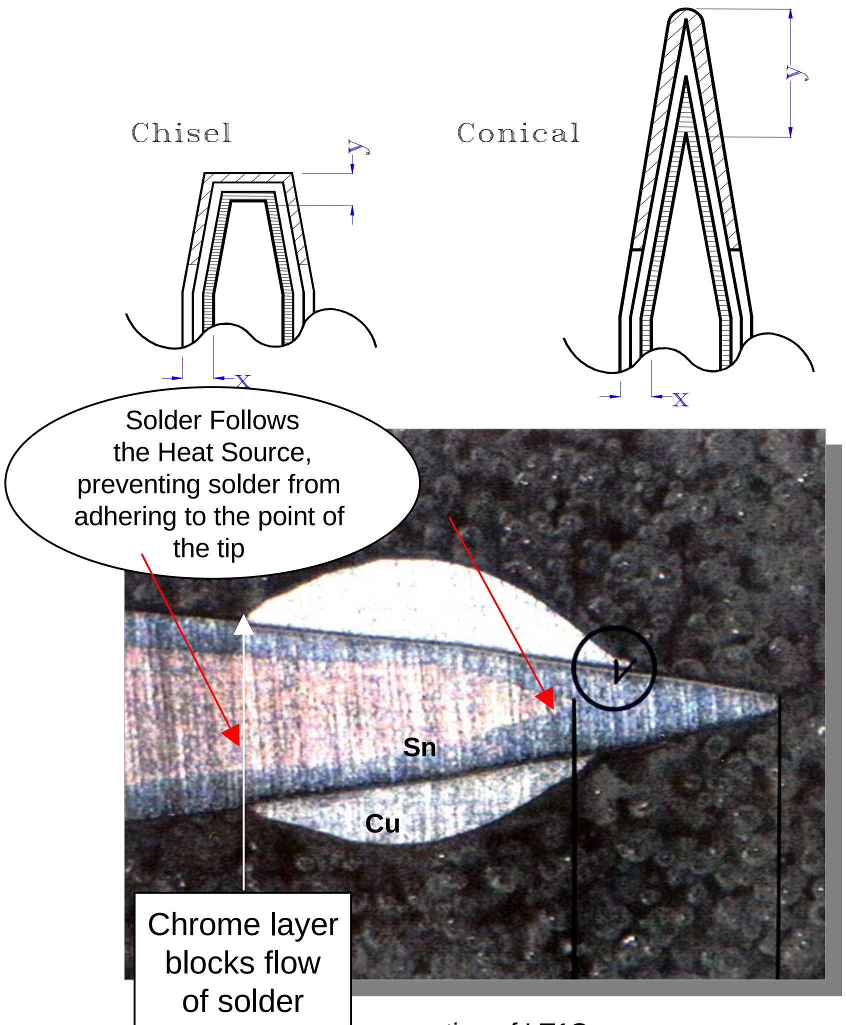


Durability test of a HT 2 soldering tip with Sn/Ag/Cu (SAC) solder alloy. Tip temperature @ 725°F

- **Reviewing the Iron Layer of a Soldering Tip**
  - Weller Soldering tips have an Iron layer thickness of between 0.006" and 0.0157" (150µm and 400µm) per side, depending on the geometry of the tip.
  - The Iron electroplating process is a highly sophisticated plating operation.
  - There is a linear relationship between the Iron thickness and the life of a tip.
  - The Iron layer has 3 important characteristics.
    - **+Plus—Long Life**
    - **+Plus - Excellent wettability**
    - **- Minus - Heat conductivity is five times lower than Copper.**

- ***Results of Increasing the Iron Layer of a Soldering Tip***
  - Weller has increased the Iron layer thickness to an optimal value for performance and durability **without** increasing end user tip cost.



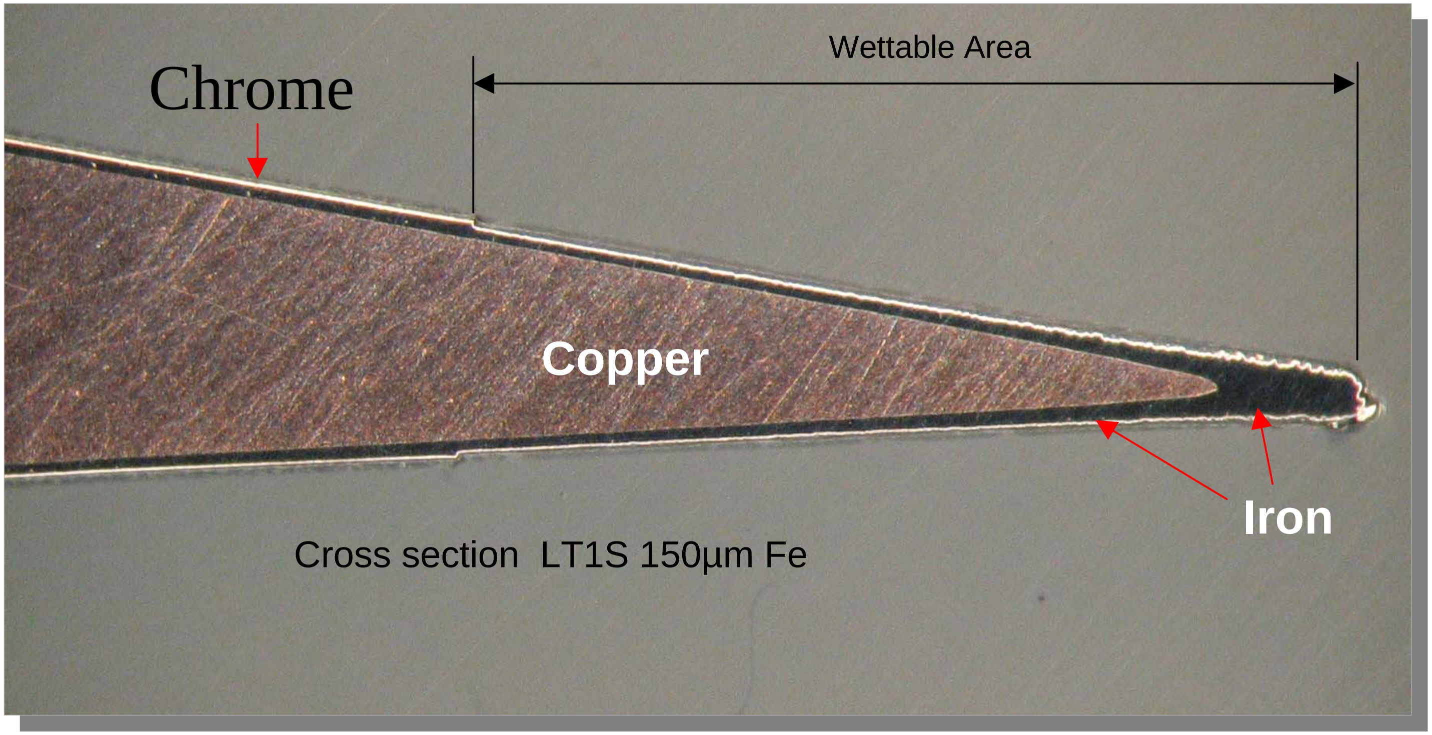


Cross section of LT1S

- ***Impact of the Geometry of a Tip to the Iron Layer Thickness***
  - The Iron layer thickness is dependent on the geometry of the soldering tip.
  - Fine Pointed Tips have more Iron on the front of the tip versus more equal Iron on Chisel and Screwdriver shaped tip styles
  - A thick Iron layer reduces heat transfer. This applies especially to fine pointed tips (conical and long shank tip styles).
  - Fine pointed tips form an area with more Iron on the end of the tip. Underneath the working area of the tip there is no Copper to efficiently transfer heat.
  - For that reason the Iron layer thickness is limited by the geometry and is approximately 0.006” (150µm) for fine pointed tips.
  - This represents the optimal balance between performance and durability.

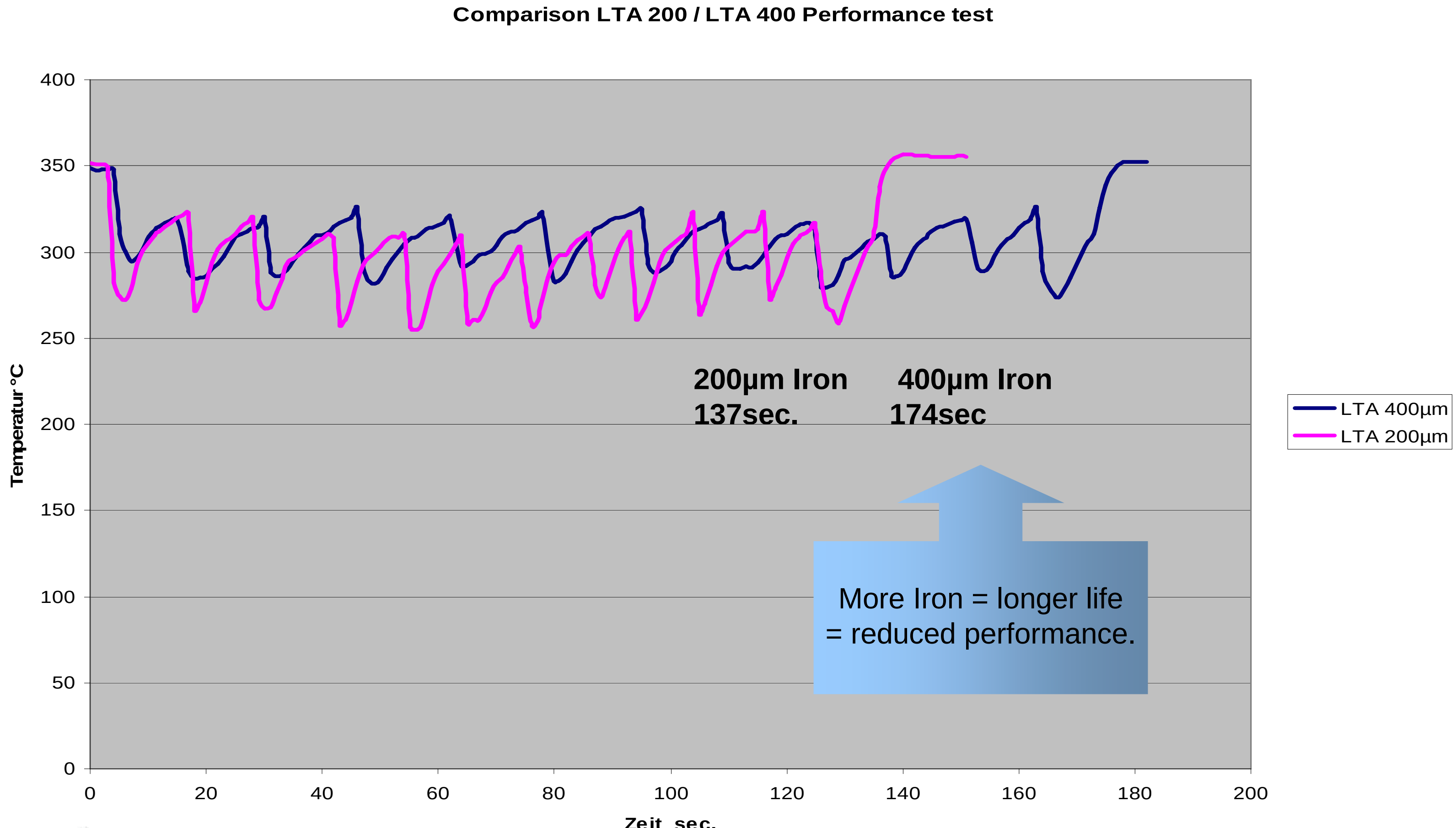
• *The Ideal Iron Layer of a Fine Pointed Tip.*

- An Iron layer of 0.006” (150µm) over the Copper core ensures the best possible heat transfer / thermal performance.
- However, the thinner Iron reduces the life of the tip in a Lead Free environment.

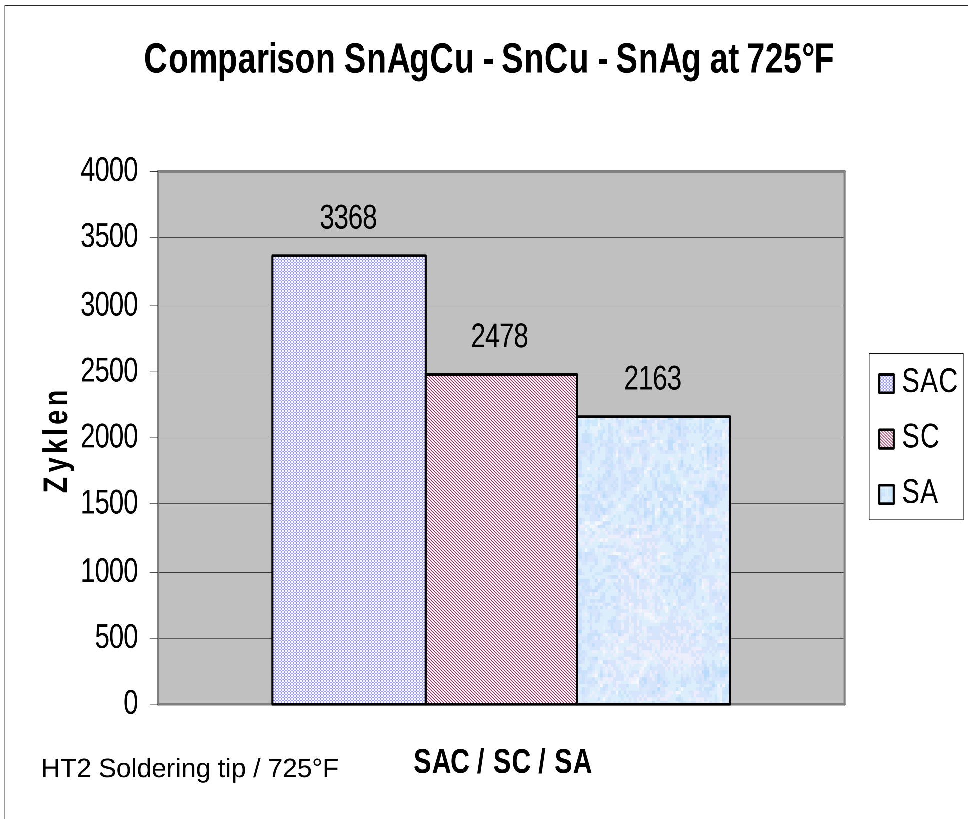


Tip Lifetime

Relationship between Iron Thickness and Performance - Comparison of an LTA with 200µm and 400µm Iron layer

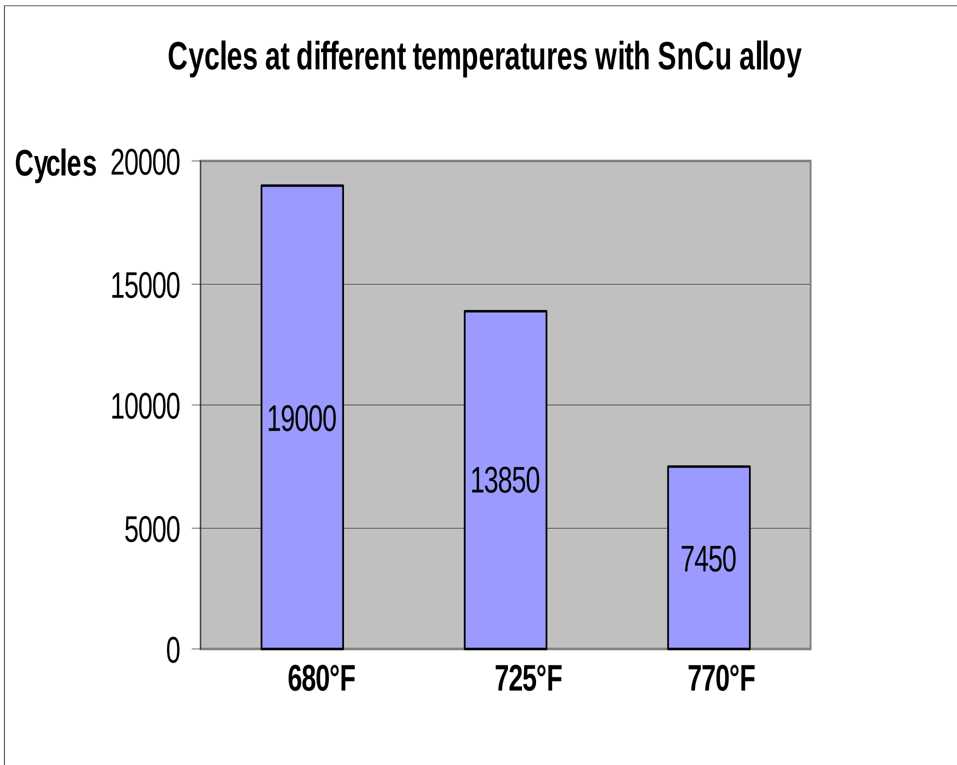


Tip Life Comparison Showing the Impact of the Solder Alloy Used



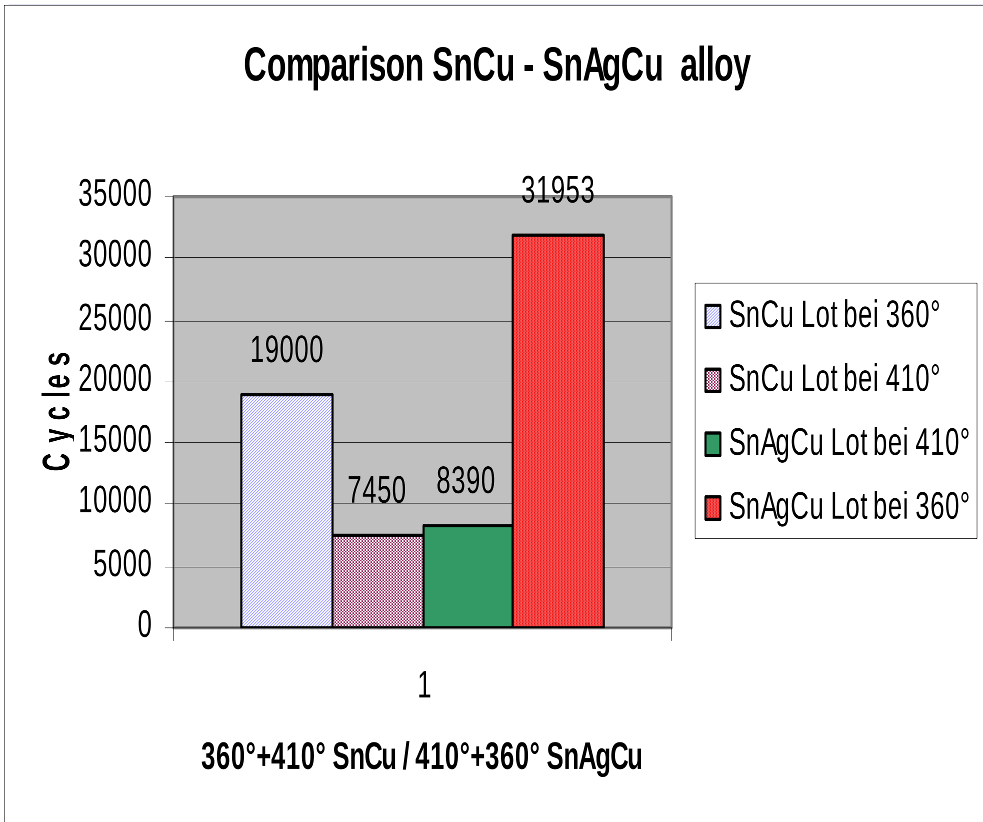
- The wear process is also dependent on the kind of solder alloy that's used.
- Comparison between three common alloys.
  - Sn 95,8 Ag 3,5 Cu 0,7 (SAC)
  - Sn 99,3 Cu 0,7 (SC)
  - Sn 96,5 Ag 3,5 (SA)
- Compared to a SAC alloy, the Tin -Copper and Tin-Silver alloys reduce the lifetime by:
  - SC **-** 25%
  - SA **-** 35%

Lifetime Comparison Showing the Impact of Tip Temperature



- Tip temperature has a significant influence on the tip lifetime.
- The corrosion and migration rates increase disproportionately.
- By using a Sn Cu alloy at 770°F versus 680°F the durability decreases by about **60%**

Impact of the Solder Alloy and Tip Temperature



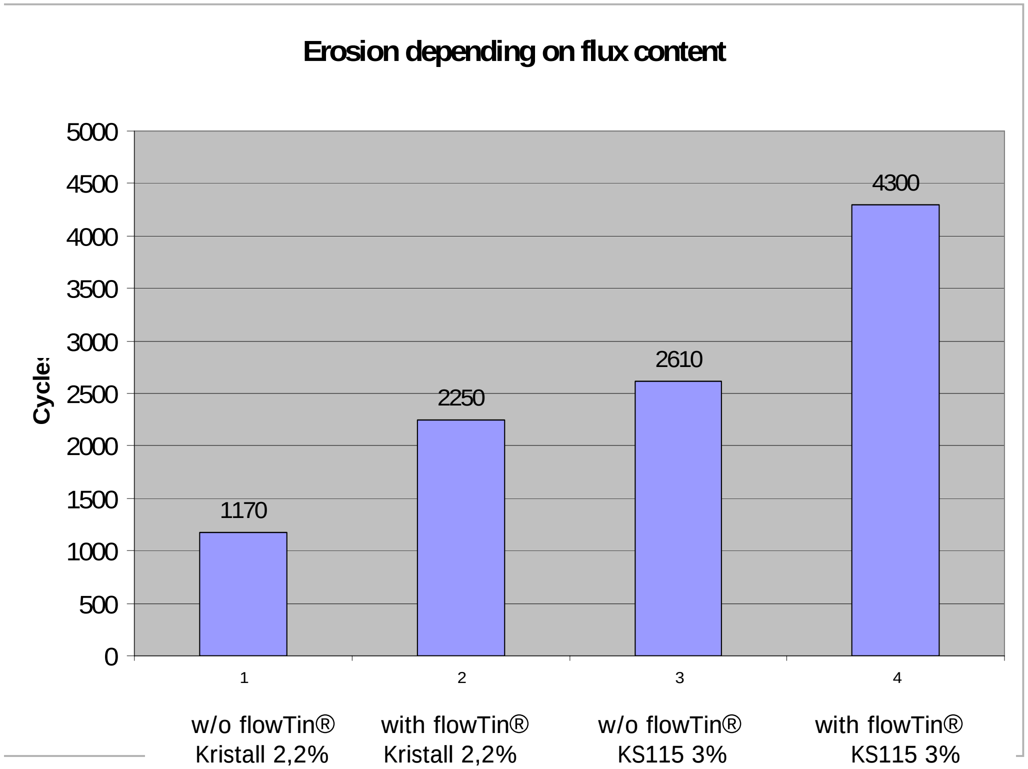
The influence of the temperature also differs with the solder alloy. We compared Sn Cu to SAC solder alloy.

- SC solder at 770 °F---lasted for 7450 cycles
- SC solder at 680 °F---lasted for 19000 cycles
- SAC solder at 770 °F---lasted for 8390 cycles
- SAC solder at 680 °F---lasted for 31953 cycles

This equates to a 77% spread between best and worst.

Tip Lifetime

New Solder Alloys with Micro Additives have been developed to reduce Migration from the Soldering Tip, Components and Boards



- Additives reduce the migration of the Iron layer into the solder.
- The additives are nickel, cobalt or rare earth in very low percentages which do not change the physical characteristics of the solder.
- Together with the new flux composition used in the micro alloys, the impact to tip lifetime is significant (up to 4 times).
- Rosin flux compositions (Kristall) create more corrosion than halogen compositions (KS115).

More info on the Weller blog in the article titled: "Lead Free - What To Do?"

New Lead Free Flux with High Solids Content

- In many cases, rosin based flux is used with a high percentage of solids content.
- A portion of the flux remains on the tip and contaminates the surface.
- The tip can no longer be used since it is non-wettable.
- The flux residues are highly aggressive and create corrosion even when the soldering Iron is in the stand.
- Proper cleaning is the most important part of tip maintenance.

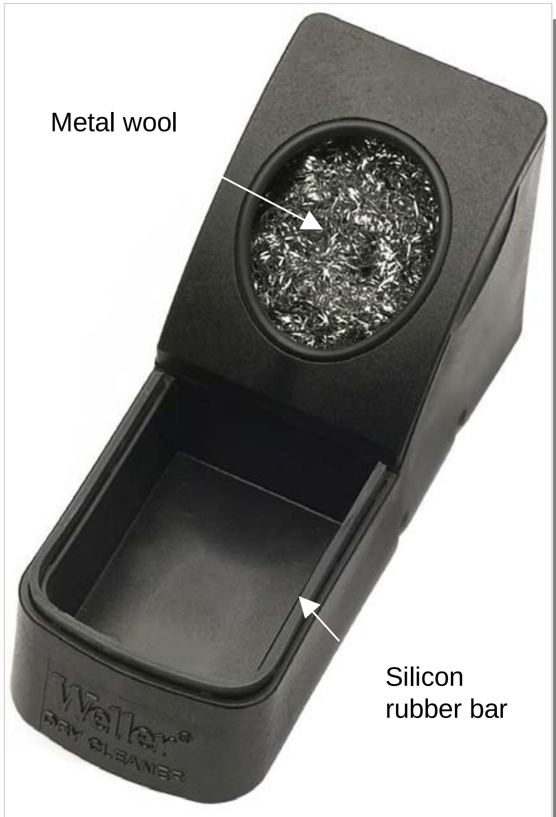
Effects of operator habits on tip life

Sponge Cleaning of the Soldering Tip

- Thermal shock of a hot tip making contact with a wet sponge may create minute fractures in the tip plating, providing openings for the alloy and flux to attack the Copper core
- Sponges remove more of the protective Tin coating from the tip than when used with a WDC Dry Tip Cleaner (sponges are better for Leaded Solders / not as good for Lead Free alloys)
- Operators normally forget to re-Tin the tip after wiping on the sponge
- Because of the cooling effect of a wet sponge, flux residues are not effectively eliminated, increasing the risk of oxidation and corrosion.
- Tap water can create non-wettable tips because they contain mineral deposits. Use Distilled or De-ionized water when using sponges.

Weller Dry Tip Cleaning

Solutions for extending tip life



- The risk of oxidation and flux residues require an optimal cleaning procedure.
- Dry cleaning with metal wool (**Weller WDC & WDC2**) is a significant improvement over wet sponge cleaning.
- Flux residues are removed and some solder remains on the tip surface after cleaning. This reduces the risk of oxidation and corrosion.
- To remove excessive solder on the tip, the WDC also includes a Silicon Rubber Bar, that can be used to gently tap off excess solder.
- Always re-Tin the tip with a sufficient amount of solder before placing the Iron back into the tool holder.

Accessories that can be used to Help Increase Tip Life

- **Stop and Go Tool Holders (WDH10T & WDH20T) - switches on the soldering tool when removed from the holder.**
- **WDC2 Dry Tip Cleaner is an optional accessory for all WDH series tool holders.**
- **WHP3000 Preheating Plate reduces the amount of heat required from the soldering tip by heating up the PCB to a pre-selected temperature. A highly efficient IR heater with equal heat distribution will improve the hand soldering process without the risk of partial over-heat.**
- **Tip Activator can be used to rejuvenate oxidized or contaminated soldering tips.**
- **WPB1 Polishing bar cleans and renews soldering tips (use only when tip is cold). Re-Tin after use with Tip Activator at a low temperature to prevent oxidation.**

WDC

WDH10T / WDH20T

WHP3000

WP80

Tip Activator and WPB1

WIIFYC & WIIFY

When visiting your customers, offer to help them solve their tip life problems when using Lead-free solder. Here's a quick summary:

- Choose the right solder tips…,the largest possible for the application. Larger tips provide better heat transfer. Larger dimensioned tips have more Iron plating, which helps to extend tip life.
- **Do not exceed 725°F. Lead-free solder does not require a higher soldering temperature**. High temperature increases tip plating erosion. Fluxes degrade faster at high temperatures and black residues remain on the tip surface. Lowering the soldering temperature reduces oxidation and reduces flux splattering.
- Chose the right solder alloy (SAC or Micro additive if possible) and flux to reduce wear of soldering tips.
- High powered soldering tools (80 - 150 Watts) with optimum temperature control can in most cases do the job at lower temperatures. **Weller WP 80 and WSP150** combine high power with optimized heat transfer.
- Dry cleaning with the **Weller WDC** keeps the tip wettable longer. Wet sponges cause thermal shock, remove the majority of the Tinning and doesn't properly remove flux residues.
- **Always Tin the tip to prevent oxidation and surface contamination.** Always apply a thin coating of solder to the tip after cleaning, and before placing in the soldering tool holder.
- **Use all available functions and accessories to reduce the tip temperature** (Standby, Auto-Off,Temperature Pre-sets, Stop and Go tool holders, etc.) or switch the soldering tools off during breaks.

Competitor Claims and Positions

- OKI
  - Auto-sleep work stands
    - Both wet and dry cleaning offered
  - Smart Heat Power Tip
    - Increased Iron plating
    - Green band around the tip to indicate Lead Free

Competitor Claims and Positions

- Hakko
  - First company to promote dry tip cleaning
  - Nitrogen generator (which is not true Nitrogen 88 - 89 % efficient)
  - Brass Tip Polisher
  - Rotating V Groove Solder Cleaner to reduce flux splatter

Competitor Claims and Positions

- Pace
  - Nitrogen generators (more efficient than Hakko - 98 % efficient)
  - Diamond soldering tips (no true advantage)

- JBC
  - Increased Iron plating