Soldering Tips & Lifetime Issues
“Coping with Lead Free”

Content

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.

What affects Tip Life?

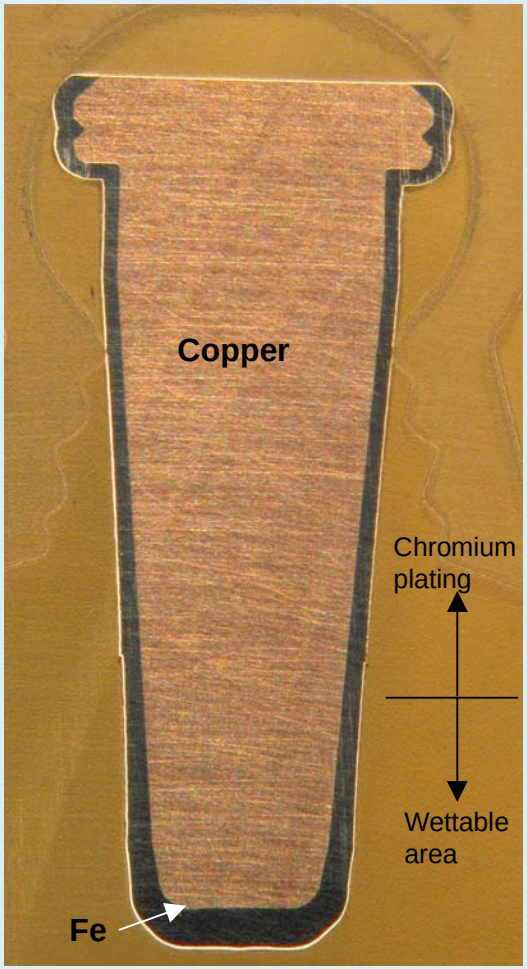
- **Tip construction**
- **Iron plating thickness**
- **Solder alloys**
- **Tip temperatures**
- **Fluxes**
- **Operator habits**

Tip Construction

How is a tip constructed?

What's the Architecture of a Soldering Tip?

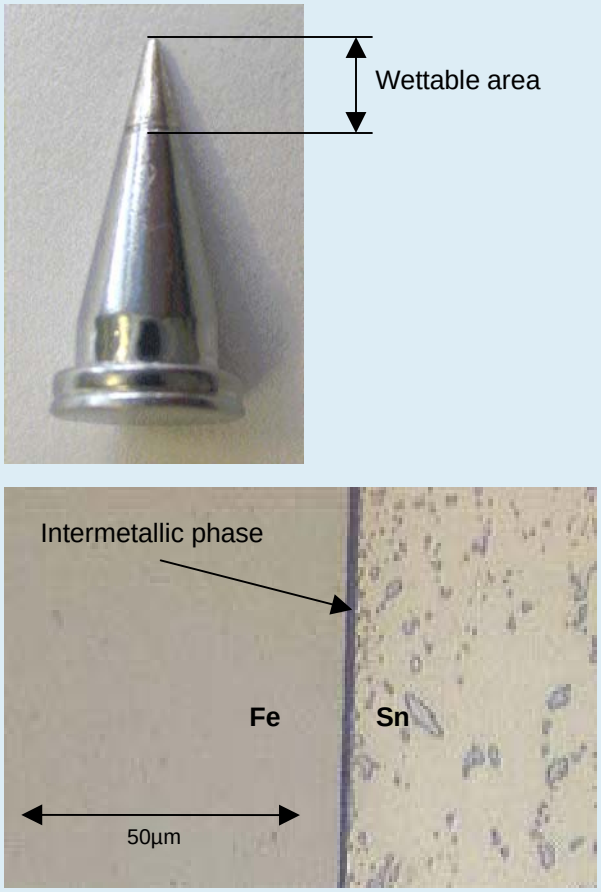
What does Wettable Area of the Soldering Tip mean?



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 Layer**
  Responsible for confining the wettable area.
- **Tinned Working Area**
  Responsible for the wettability of the soldering tip.
- **Lead-free Tinning**
  Responsible for proper wettability from the beginning of usage when brand new.



Wettable Area of the Soldering Tip

- The wettable area is the working area and responsible for the heat transfer.
- The reason for tinning is to produce an intermetallic bond between the iron layer (Fe) and the solder alloy (Sn).
- When the intermetallic bond is created the tip is tinned and remains wettable.
- The thickness of the intermetallic phase grows over time. A higher temperature accelerates the growing rate. This will lead to more dissolving of the iron, more erosion and to a higher risk of oxidation.

Tip Appearance

Soldering tip defects

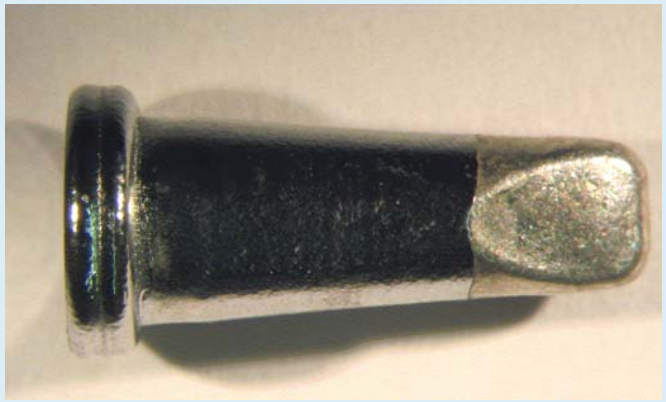
What does a “worn-out” soldering tip look like?

What does an oxidized tip look like?

Soldering Tip Defects

- The change from lead containing solder alloy to lead free has a significant influence on the durability of soldering tips in manual soldering operations. The higher percentage of tin and the higher melting temperature of the lead free solder act more aggressively on the soldering tip and accelerates the reduction of the tip life. In addition, lead-free solders typically use a more aggressive flux formulation.
- The biggest reasons for soldering tip defects:
  - **Worn out iron layer (erosion).**
  - **Unwettable iron layer (oxidation).**
- With suitable treatment of the soldering tip, lifetime can be increased to a reasonable value, even using lead free solder.

What does a “worn-out” soldering tip look like?



LTC Soldering Tip

Brand New

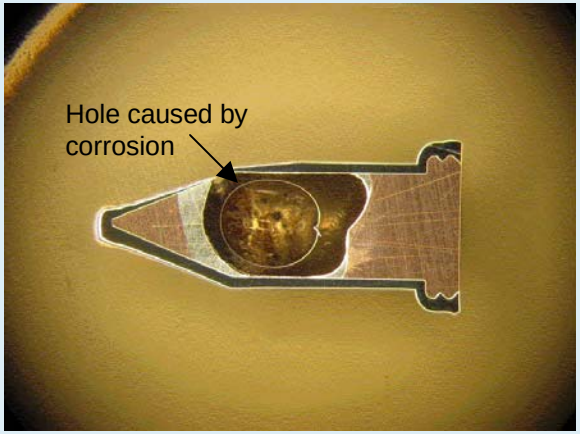
Soldering process

LTC Soldering Tip

Worn Out

Customer feedback

Used up LTC tip

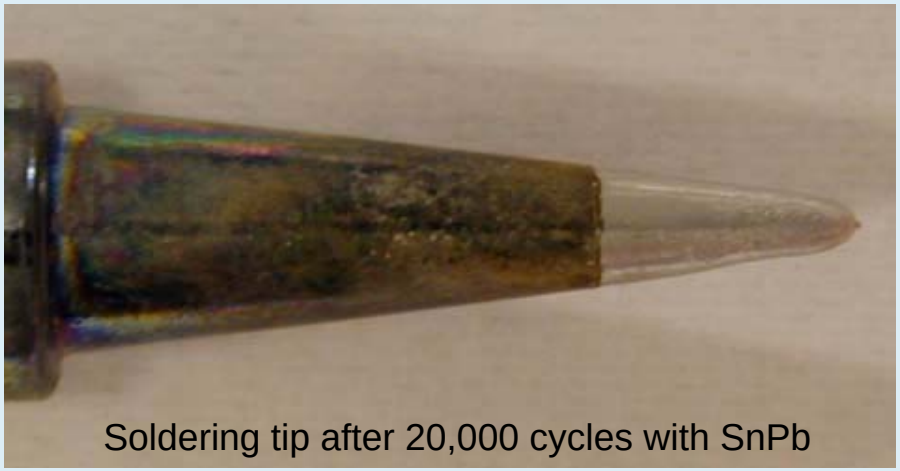


Cross section of a worn out
LTC soldering tip

- Sooner or later the soldering tip is worn out by the soldering operations. This means that the iron layer which protects the copper core material is used up. The unprotected copper disappears very fast because of the extreme high migration rate and corrosion rate of copper.
- The conclusion is the durability of the soldering tip is related to the iron layer thickness.
- As soon as the iron layer is worn out the life of the tip is over and this condition will be signaled by a hole in the copper core.
- The wearing process can be divided into three effects.
  - **Corrosion caused by fluxes**
  - **Migration of the iron plating into the tin solder**
  - **Mechanical stress caused by abrasive cleaning or “aggressive’ soldering.**
- A soldering tip is a wearing part (much like tires on a car) and a worn out tip is not a tip defect.

Oxidation of a Soldering Tip

- A soldering tip will oxidize due to the oxygen atmosphere and create an metallic inactive surface.
- The oxidized surface can often not be reactivated by common flux and remains unwettable.
- The heat transfer of an unwettable soldering tip is significant lower.
- The risk of oxidation grows with increasing tip temperature (840°F < 1min).
- A proper solder coated tip will prevent the influence of the oxygen atmosphere and avoid the oxidation.
- Correct maintenance of the soldering tip will reduce the risk of oxidation and unwettability.



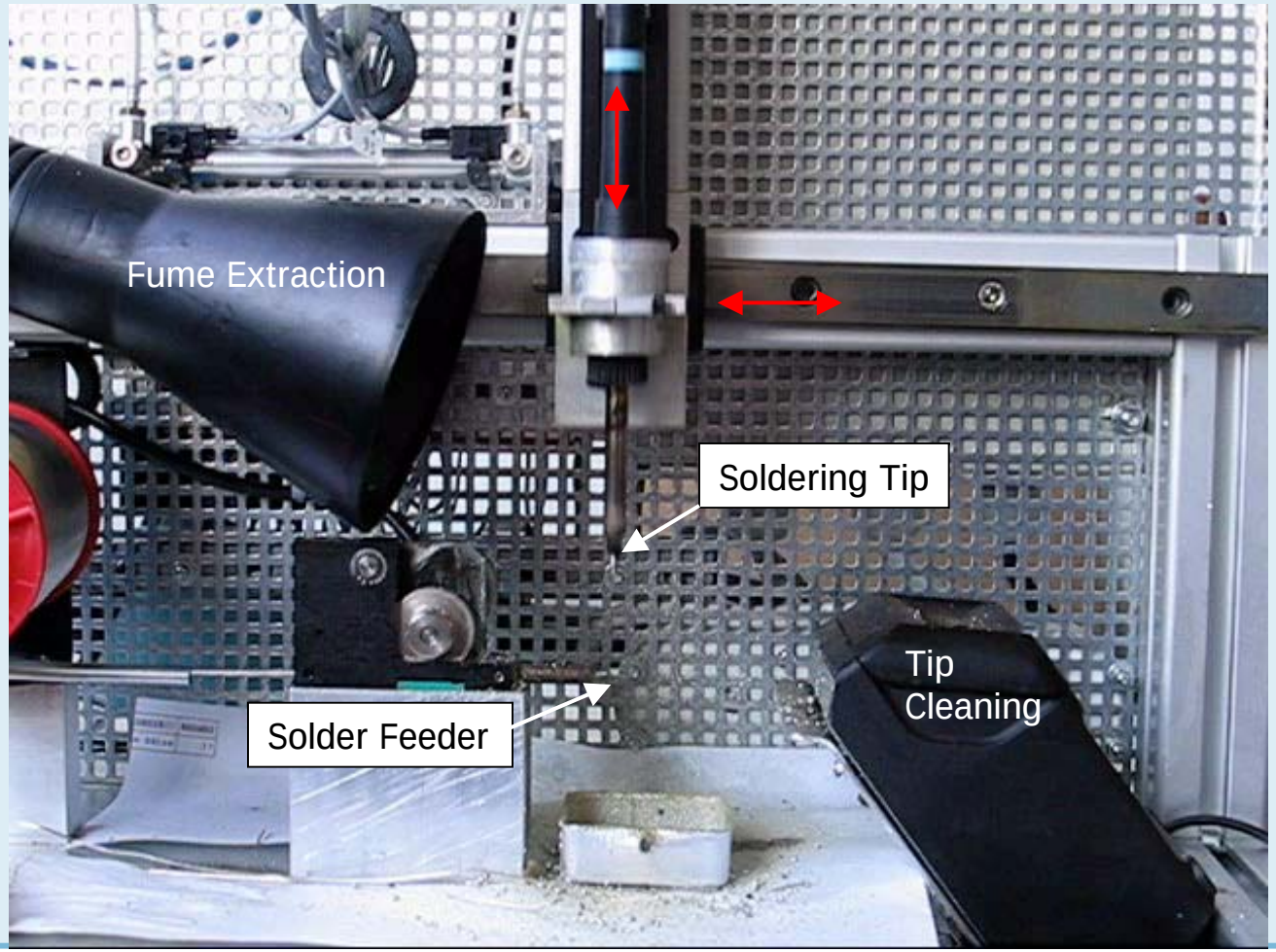
Soldering tip after 20,000 cycles with SnPb

Soldering tip after 10,000 cycles with lead free SAC

Wearing of the Soldering Tip

- The copper core of the soldering tip is covered by a iron layer. The iron layer protects tips against **corrosion** caused by the flux and metallic **migration** caused by the solder alloy**.**
- The content of nearly 95% of tin in lead free alloys increases the problem of migration (dissolution). This reflects a new issue in lead free environment.
- The corrosion rate, the migration rate along with the abrasion of the iron layer is dependent on the solder alloy and the tip temperature
- Mechanical stress, due to the solder application, is also a contributor to additional abrasion.

Equipment Established to Test and Optimize Tip Lifetime



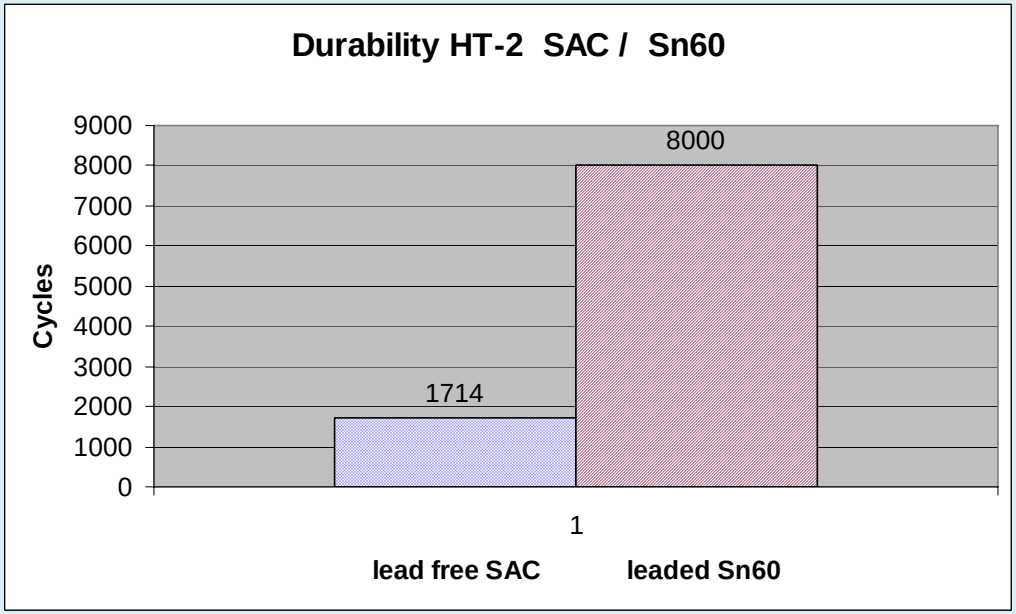
Test equipment avoids long term customer tests.

Test equipment delivers reliable and reproducible results.

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

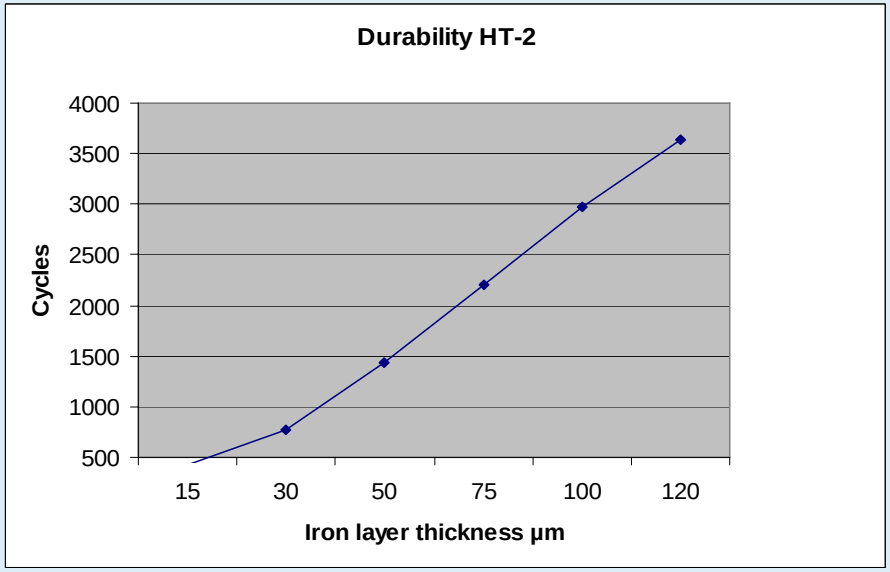
Lifetime under the Influence of Lead free Solder

- Comparison Sn95,8Ag3,5Cu0,7 to Sn60Pb
- SAC alloy wears the tip 4 to 5 times faster than lead containing solder.



Test with reduced iron layer thickness / 725°F

The Iron Layer of a Soldering Tip



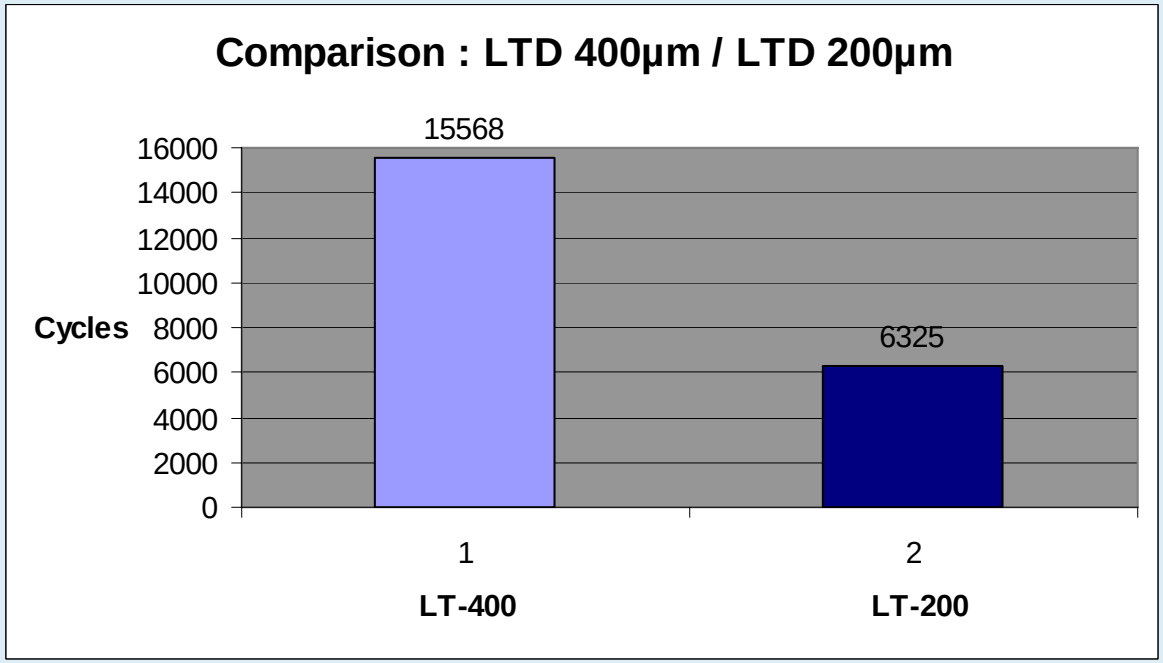
Durability test of a HT 2 soldering tip with SnAgCu (SAC) solder alloy. Tip temperature 725°F

- On LT series Weller tips the copper core is covered by a plated iron layer. The layer thickness is between 150µm and 400µm depending on the geometry of the tip.
- The electroplating treatment process is highly sophisticated.
- There is a linear relationship between the iron layer thickness and the lifetime.
- The iron layer has 3 important characteristics.
  - **Plus--Wear Protection**
  - **Plus--Good wettability**
  - **Minus--Heat conductivity is five times lower than copper.**

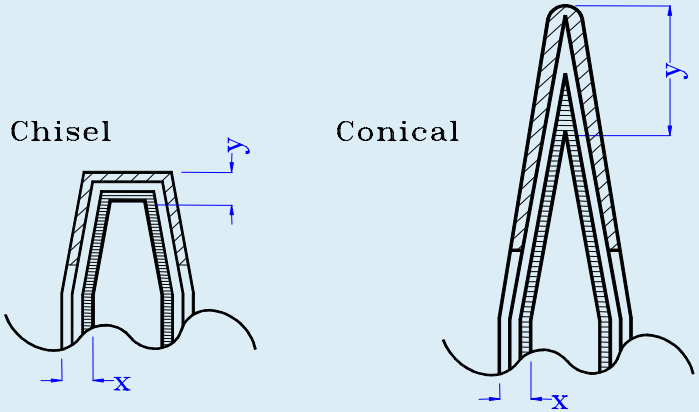
Weller®

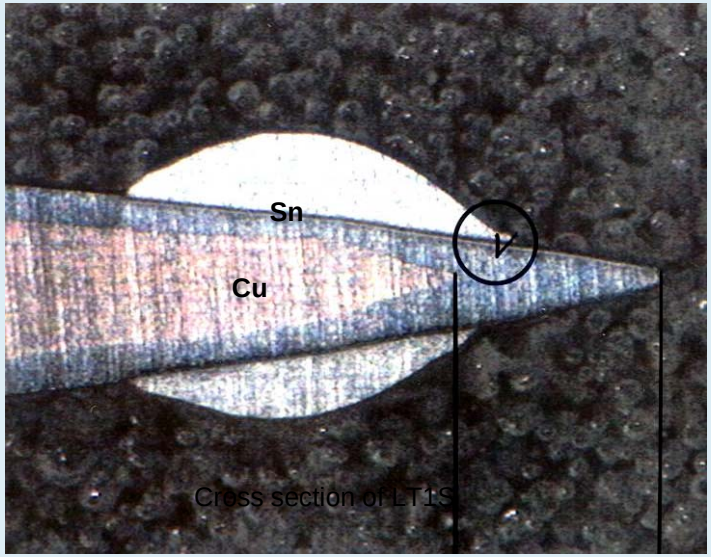
Increasing the Iron Layer as a preventative measure against faster wearing of Tips.

- Weller increased the iron layer thickness to an optimal value for performance and durability.



COOPER Hand Tools

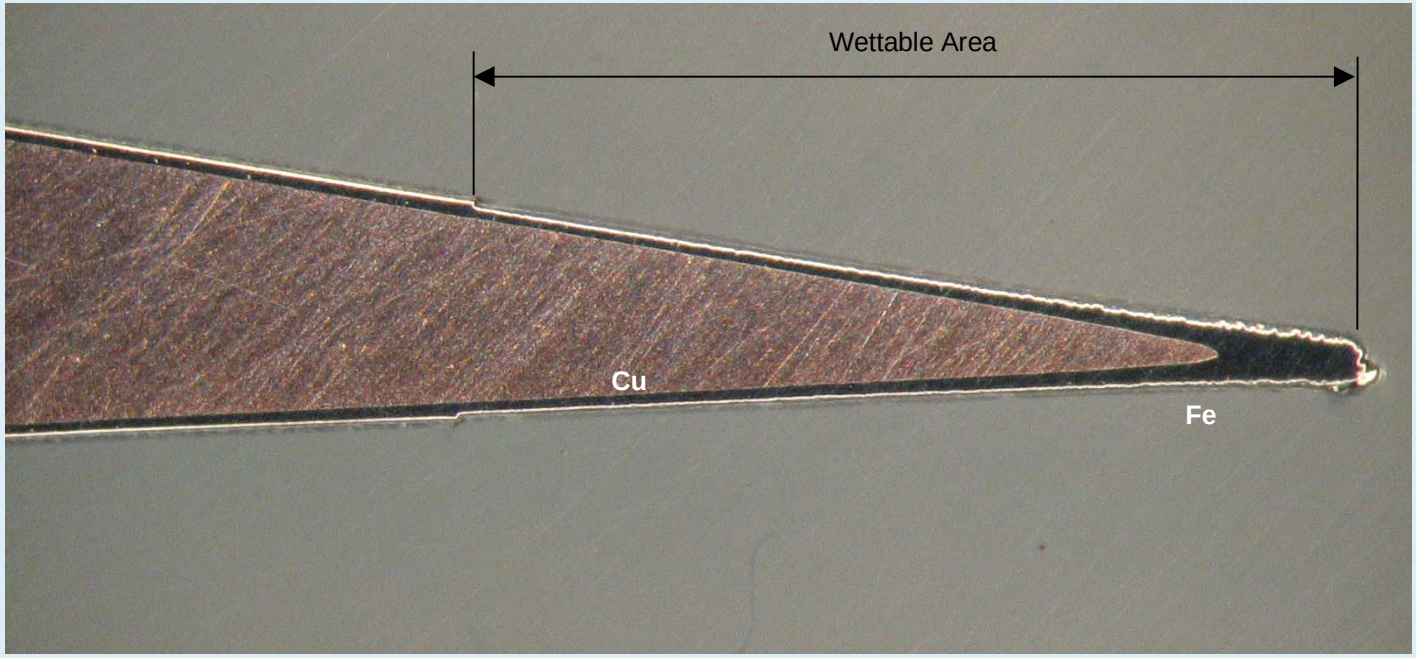




Impact of the Geometry of the Tip to the Iron Layer Thickness.

- The iron layer thickness is optimally adapted to the geometry of the soldering tip.
- A thick iron layer reduces the heat transfer. This applies especially to fine pointed tips (conical types).
- These fine pointed tips form an area with iron only on the front side. 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 around 150µm for fine pointed tips. This represent the optimal balance between performance and durability.

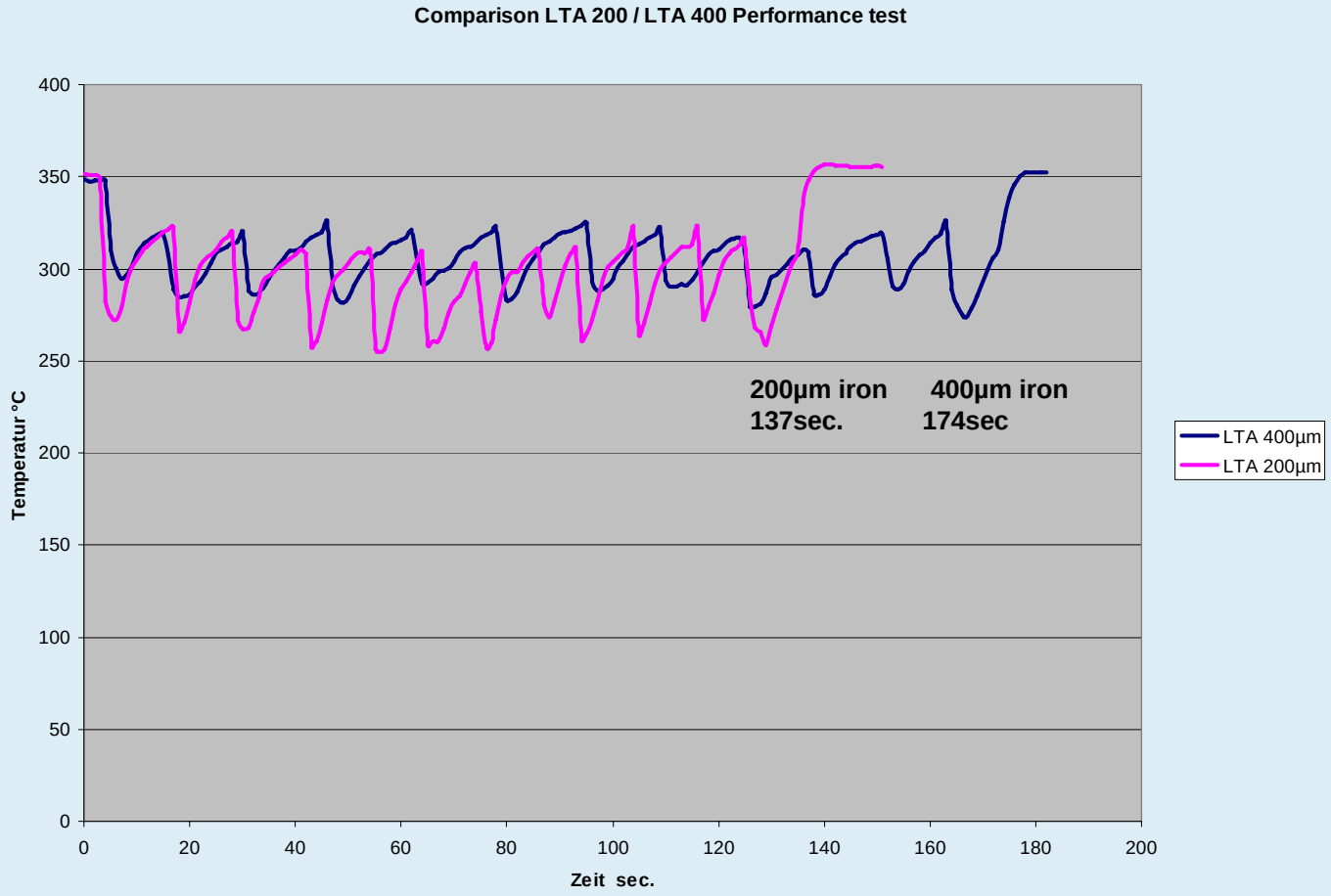
- ***The Ideal Iron Layer of a Fine Pointed Tip.***
  - With a 150µm iron layer there is copper under the whole working area. This ensures the best possible performance.



Cross section LT1S 150µm Fe

- ***Relationship between Iron Thickness and Performance***

Performance test with a LTA tip with 200µm compared to 400µm iron layer



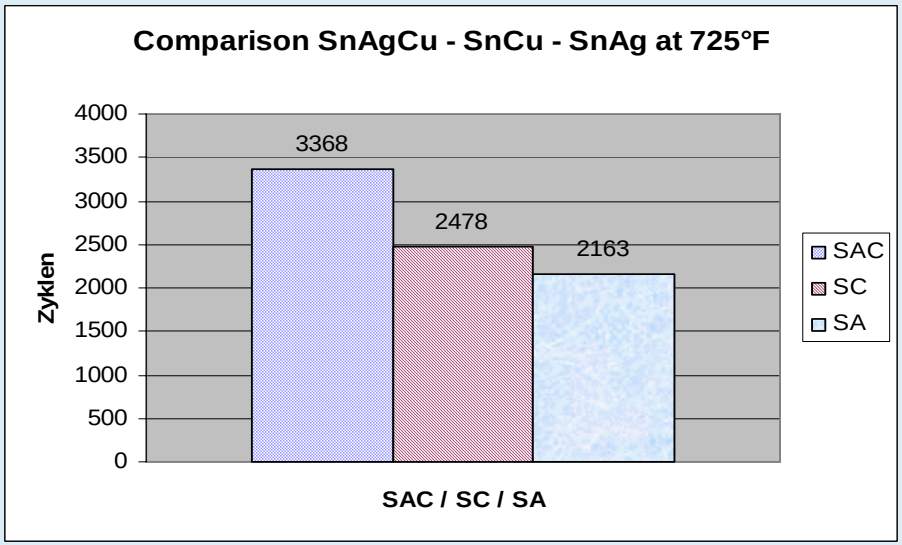
What else besides iron plating thickness affects tip life?

Effects of the types of lead free solder alloys

Effects of soldering temperatures on tip life

Effects of operator habits on tip life

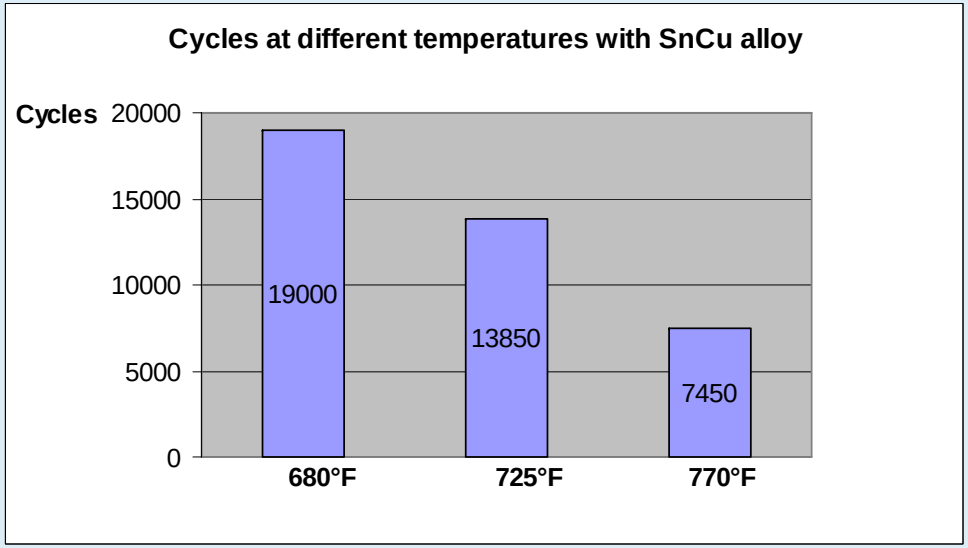
Lifetime Comparison Showing the Impact of the Solder Alloy Used



HT2 Soldering tip / 725°F

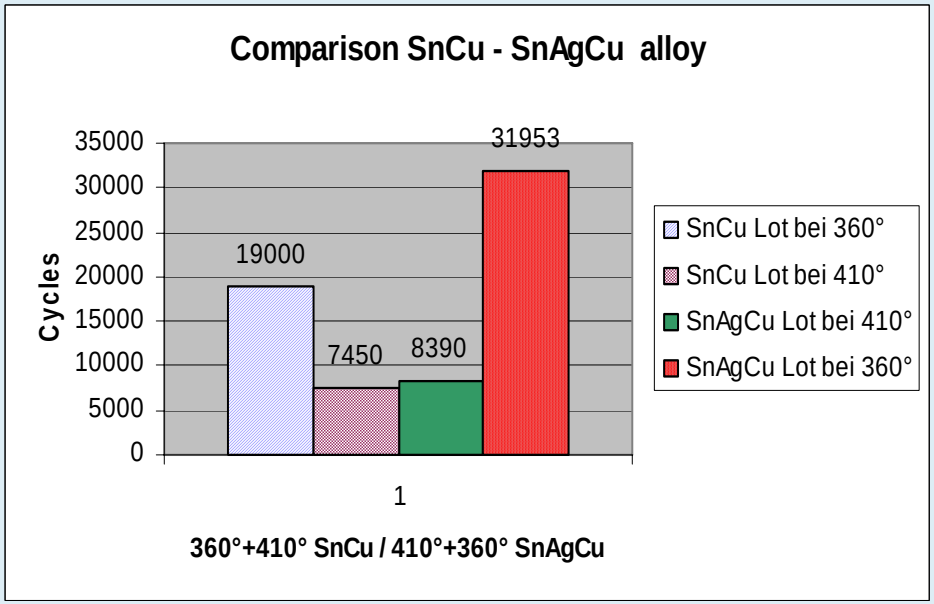
- The wear process is also dependent on the kind of solder alloy that's used.
- Comparison between three common alloys.
  - Sn95,8Ag3,5Cu0,7 (SAC)
  - Sn99,3Cu0,7 (SC)
  - Sn96,5Ag3,5 (SA)
- Compared to SAC solder the Tin-Copper and Tin-Silver alloys reduces the lifetime by:
  - SC - 25%
  - SA - 35%

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 SC alloy at 770°F versus 680°F the durability decreases by about **60%**

Impact of the Solder Alloy and Tip Temperature

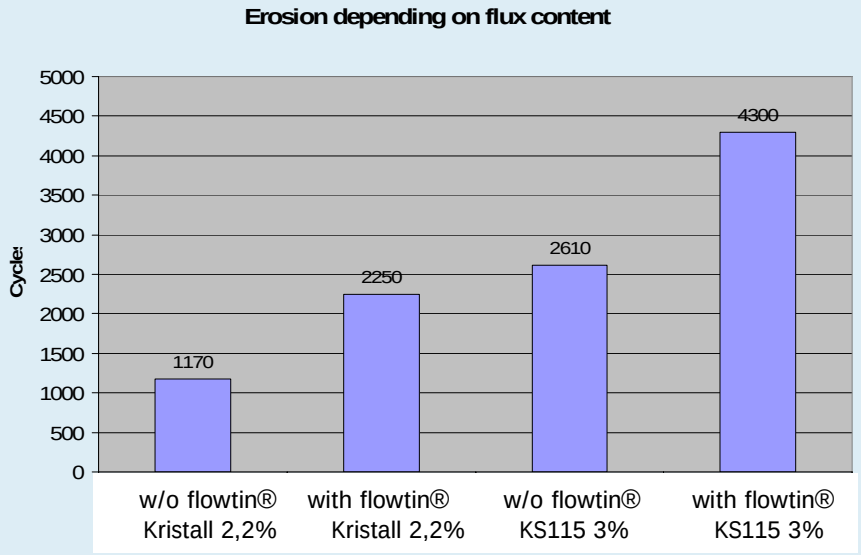


The influence of the temperature also differs with the solder alloy. We compared SC to SAC solder alloy.

- 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.

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 solid content.
- A portion of the flux remains on the tip and coats the surface.
- The tip can no longer be used since it is unwettable.
- The flux residues are highly aggressive and create corrosion as well when the soldering iron is in the rest.
- Efficient cleaning is a very important part of maintenance.

Effects of operator habits of tip life

- ***Sponge Cleaning of the Soldering Tip***

- Thermal shock of a hot tip hitting a wet sponge creates minute fractures in the tip plating providing openings for attack on the copper core
- Any solder coating is removed from the tip
- Operator usually forgets 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 at the same time.
- Not using distilled water can create unwettable tips because of mineral deposits

Dry Cleaning of the Soldering Tip

- The higher risk of oxidation and more flux residues require an optimized cleaning procedure.
- Dry cleaning with a metal wool (**Weller WDC**) is a significant improvement.
- Remaining solder on the tip surface in combination with effectively eliminating the flux residues, reduces the risk of oxidation and corrosion at the same time.
- To get rid of excessive solder material on the tip, the WDC with the silicon bar, can be carefully used as a tapping box.
- Always re-tin the tip with a sufficient amount of solder before placing the iron in the holder.

Accessories to Lower Tip Wear and Soldering Temperatures

- Stop and Go holder WDH10/20T switches on the soldering tool when removed from the holder.
- WDC2 Dry cleaner is a accessory for all WDH holders.
- Preheating plate WHP3000 reduces the amount of heat required of the soldering tip by heating up the PCB to a chosen temperature. Highly efficient IR heater with equal heat distribution will support the hand soldering process without risk of partial over heat.
- Tip activator can be used to reactivate oxidized tips.
- Polishing bar WPB1: Cleans and renews soldering tips (in cold condition). Re-tin after use with tip activator at a low temperature to prevent oxidation.

WDC

WDH10/20T

WHP3000

WP80

Tip Activator and WPB1

Test Results Summary

- Tip Lifetime and iron layer thickness is a linear relationship.
- Best lifetime and performance is given by an optimized iron layer thickness.
- Lead-free solder wears the tips 4 to 5 times faster than lead containing solder.
- The wear of the tip depends on the solder alloy used and on the composition of the flux
- Temperature is a key factor in tip lifetime. Corrosion, migration (iron plating dissolution) and also oxidation increase over-proportionally with the temperature.

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. **Use always the biggest possible tip** out of the offering. Bigger tips give a better heat transfer. Use tips with heavy iron plating.
- **Do not exceed 725°F. Lead-free solder does not require a higher soldering temperature**. The wear rate increases significantly. Flux is worn out fast and black residues remain on the tip surface. Lowering the soldering temperature reduce oxidation and reduces splashing of flux.
- Chose the right solder alloy (SAC or Micro additive if possible) and flux to reduce wear of soldering tips.
- The right, powerful soldering tool with optimal temperature control, can in most cases do the job at a lower temperature. **Weller WSP 80** and **WP 80** combine high powered heaters with optimized heat transfer and handy design.
- Dry cleaning with the **Weller WDC** keeps the tip wettable for the longest time. Wet sponges cause thermal shock, remove the tinning and don't remove flux residue.
- **Always take care to properly tin the tip to prevent oxidation.**
  Never clean a soldering tip right before putting the tool in the holder without applying solder to the tip.
- **Use all functions and accessories to reduce the tip temperature** (standby, auto off, stop and go holder) or switch off the soldering tools during breaks.

Beware of False Claims & Info About Tip Life

To our knowledge no one has developed any soldering tip technology that will improve tip life

There are no new material or coating breakthroughs at this point in time regardless of whatever “spins“ you may have heard (Diamond Dust)!

Weller®

Check Out our various tip samples and accessories on the table

COOPER Hand Tools