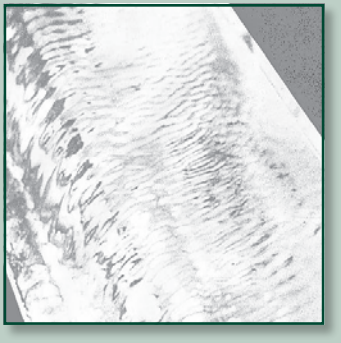
Wave Soldering



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Wave soldering is still preferred for many kinds of assembly operations and often complements reflow assembly. Wave soldering is particularly suited to continuous production. Changes to board sizes and configurations are readily accommodated; however, operators need to be skilled and processes optimized to realize the most cost-effective wave soldering production output.

Modern wave solder machines have become very user-friendly. They are used to solder a wide variety of assemblies, including mixed-technology boards. Full enclosures with microprocessors control inert atmospheres for improved low-dross soldering.

Wave solder production lines include fluxing, preheating, soldering, and a conveyor system to transport the circuit assembly through the process. Cleaning and drying can also be added to the soldering system.

Flux is commonly applied by a spray, foam, or wave process. Fluxes (with different activity levels) are available in no-clean, water-washable, and VOC-Free varieties. The solder is melted in a solder pot and pumped to produce a "wave." The board is conveyed over the flux, preheat, and solder wave stations to complete the joints. Although 63Sn is the commonly used alloy for wave soldering, Pb-Free alloys are also available.

The molten solder thermodynamics and fluid mechanic characteristics contribute to the wetting of the metal surfaces, provide through-hole fill, and form reliable solder joints.

Process Steps

The wave soldering process is made up of several steps: flux application, preheat, solder wave, and possibly cleaning. All of these steps work together to form a functional, reliable, and cost-effective finished product.

As with any process, control of process variables will have a direct affect on the quality of the final product. These variables include:

- Conveyor angle
- Conveyor speed
- Flux type
- Flux density
- Amount of flux deposited
- Preheat temperature
- Solder alloy composition
- Solder purity
- Solder temperature
- Wave form, height, stability and speed of flow
- Height and stability of flux head
- Depth of immersion
- Atmosphere
- Cleanliness

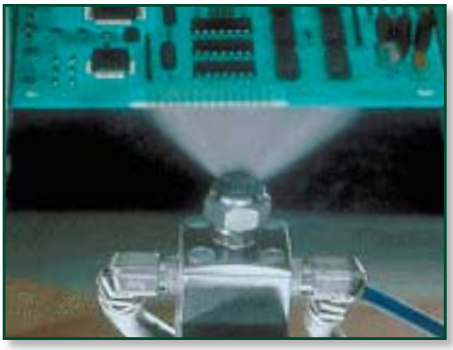
Choosing the Right Flux

There are many types of soldering fluxes. Picking the correct flux chemistry depends on a number of factors, including:

- The solderability level of the parts to be assembled
- The type of finish or coating used on the assembly
- The flux application method
- Cleaning requirements of the assembly
- The application environment of the completed assembly

Flux Application

The key to fluxing is to deposit an even coverage of flux on the underside of the board and within plated through-holes, reliably and consistently.



Spray Flux Process Controls

- Control flux deposition
- Control over spray
- Use air knife to remove excess flux (if fitted)

Foam Flux Process Controls

- Check specific gravity during use
- Maintain level in foam fluxer
- Change flux periodically
- Use clean oil-free air

Preheat

Preheat is used to prepare the printed circuit assembly for contact with the solder wave. Preheaters come in a variety of configurations including topside and bottomside sections using infrared, quartz, calrod, and convection technology.

The Preheat Process:

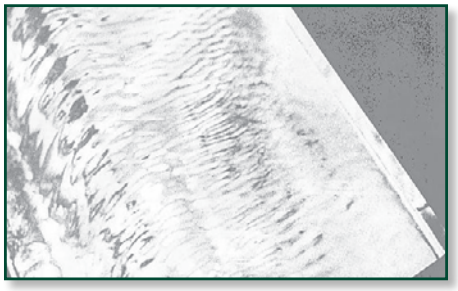
- Dries the flux
- Activates the flux
- Heats board and components to increase production speed
- Reduces thermal shock on board and components

Solder Wave

A variety of wave forms are used in wave soldering, including single and dual wave configurations.

The Solder Wave:

- Raises the temperature of the areas to be soldered
- Triggers flux activation
- Delivers solder to component leads, terminals, plated through-holes and pads



Wave Solder Variables:

- Solder wave temperature (for Sn/Pb soldering) is typically 250-260°C (480-500°F)
- The wave height can be controlled by the solder pump speed
- The wave height should be set at 1/2 to 2/3 of the thickness of board
- Ensure the solder nozzle is level and that the solder flows evenly across its width

Cleaning

The key to a consistent cleaning process is control of the cleaning chemistry and rinse water quality. Periodic assessment of the assembly's cleanliness verifies the efficiency of the process.

During the cleaning process, you should control the concentration and temperature of the cleaning chemistry according to product recommendations. Rinse water is typically heated to 49-60°C (120-140°F). Using conductivity controlled deionized water in the final rinse provides best results.

Working Practices of Wave Soldering

Statistical Process Control should be used to assess the capability of a manufacturing process. This information should be a part of an overall process improvement initiative.

- Chart the machine performance – production levels, process quality and defect rates, downtime, maintenance programs, assembly and bare board cleanliness, etc.
- Keep the equipment clean and well-maintained, removing solder and flux splashes.
- Ensure that all doors and panels are in place prior to operating.
- Leave good access around the equipment for maintenance, recharging, etc.
- Use profiling equipment to check immersion time, immersion depth, preheat temperature, and conveyer setup. This will simplify machine setup time.
- Periodically use a descaler in cleaning equipment. This will minimize spray nozzles plugging and improve the overall cleaning process efficiency.

Flux Handling

It is always best to be cautious when working with soldering fluxes or any chemical. Before handling, read and understand the information on the Material Safety Data Sheet (MSDS) and Product Data Sheet.

Safety Tips:

- Wear safety glasses and non-absorbent gloves when handling flux.
- Avoid skin contact. Wash with soap and water if contact does occur.
- Do not allow any flame or spark near liquid flux.
- Avoid inhaling flux fumes.
- Use flux containers that are easy to handle.
- Ensure fume extraction equipment is operating efficiently.
- Avoid flux contact with preheat surfaces.
- Keep spray fluxers and flux stones clean and free from clogging.

Flux Storage

- VOC-Based fluxes and thinners have low flash points and are classified as flammable liquids; handle with care.
- Keep containers tightly closed and store bulk supplies only in an approved flammable materials area.
- Observe the hazard safety guidance on the drum label at all times.
- VOC-Free fluxes present no flammability risk, reducing storage and use restrictions.

Solder Wave Maintenance

Regular solder wave analysis should be part of an overall quality assurance program. Any build-up of metallic contamination will have a detrimental effect on defect rates.

- Regularly submit solder samples for chemical analysis (i.e. every six months).
- Follow the equipment manufacturer's recommendation for cleaning the solder pot and for solder removal.
- Monitor the solder pot temperature using an independent thermometer to compare with machine readings.
- Keep the solder at recommended levels. Low solder produces increased dross.
- To eliminate metallic contamination, use stainless steel utensils to remove solder and dross.
- Do not allow water or other liquid to come into contact with molten solder.
- In case air has become entrapped during cool-down, use caution during re-melt to avoid the risk of solder spitting.
- Heat resistant gloves and face, eye and respiratory protective equipment should be worn during dross removal.
- Disposal of solder and dross is regulated. They must be processed by a licensed facility. For safe disposal, call your site dross recovery service.

Cleaning Process Effluent

Rinse water containing flux residues, rinse aids, or cleaning chemistry should be characterized prior to release or disposal; pre-treatment (filtration, ion exchange and neutralization) may be required. Contact your local water reclamation authorities or an authorized waste reclamation site for regulations and proper disposal methods.

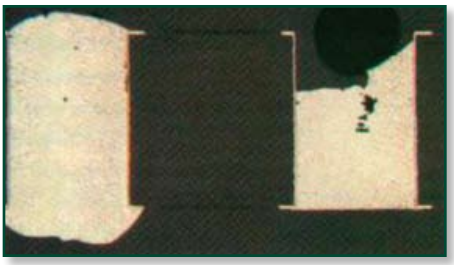
Rinse water contaminants may include:

- Biological Oxygen Demand (BOD)
- Dissolved lead
- Low or high pH

Troubleshooting

Insufficient Hole Fill

Complete Fill **Incomplete Fill**



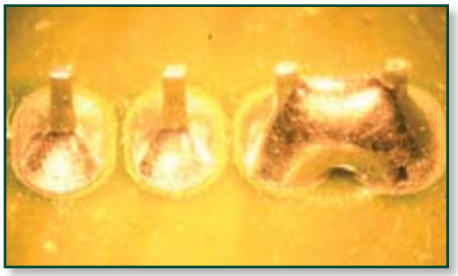
Possible causes include:

- Solder temperature is too low
- Solder is contaminated
- Solder wave is uneven
- Preheat temperature is too high/low
- Flux is contaminated or its specific gravity is too low
- Fluxer is set incorrectly
- Conveyor speed is too high or the angle is too small
- Board or components have poor solderability
- Insufficient flux activity

Bridging/Icicles

Possible causes are:

- Solder temperature too low
- Solder wave too high or uneven
- Solder is contaminated
- Preheat temperature incorrectly set (too high/low)
- Flux is contaminated or its specific gravity is too low
- Fluxer is set incorrectly
- Conveyor speed is too high or angle is too small
- Poor solderability of board or components
- Component leads are too long
- Excessive solder deposition
- Insufficient flux activity

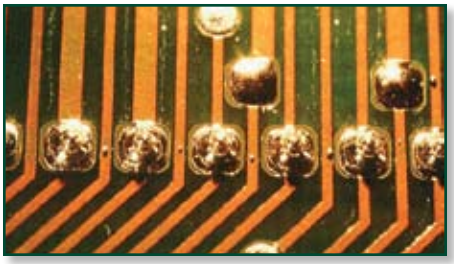


Solder Balls

Possible causes are :

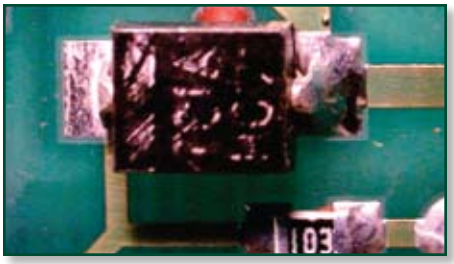
- Preheat temperature is set incorrectly (too high/low)
- Solder temperature is too high
- Solder wave is too high or uneven
- Flux is contaminated or its specific gravity is too low
- Excessive flux
- Conveyor speed is too high
- Poor solder mask
- Ineffective curing

Skips

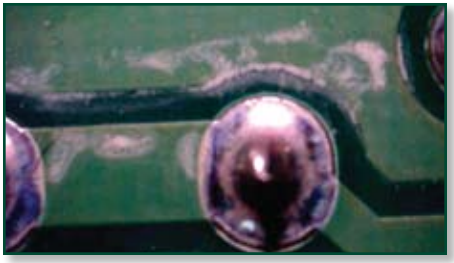


Possible causes are:

- Solder wave is too low or uneven
- Preheat is too high
- Flux is contaminated
- Specific gravity is too high
- Flux is not making contact, i.e. fluxer set too low or uneven
- Excessive flux blow-off
- Conveyor speed too high
- Shadowing of components – use dual wave



Electrochemical Migration and Reduced SIR Values



Possible causes are:

- Chloride or other ionic residue on the bare board and/or components
- Hygroscopic residue on the bare board and/or components
- Ineffective cleaning during the bare board fabrication or after soldering the assembly
- Improper use of no-clean solder flux chemistry
- Ineffective cleaning process

Cosmetic Appearance

Possible causes are:

- Excess flux deposition
- Preheat temperature is too low
- Contact time in solder wave is too low
- Cleaning process is ineffective
- Too much time elapsed before cleaning
- Poor solder mask
- Ineffective curing

Pb-Free Wave Soldering

Many of the items discussed so far are applicable to all wave soldering, including Pb-Free; however, Pb-Free wave soldering does offer unique challenges.

- The increase in the temperature required for soldering Pb-Free alloys may require a change in flux chemistry.
- Equipment upgrades (solder pot compatible with Pb-Free solders) may be required.
- Process optimization for implementing Pb-Free is likely necessary.

For more help with your transition to Pb-Free, see our FREE Pb-Free Readiness Assessment tool at www.Pb-Free.com.

Flux Chemistry

The popular no-clean flux chemistry may be stressed when addressing the needs of Pb-Free wave soldering. Increased preheat temperatures, slower conveyor speeds, longer dwell time in the solder, higher solder temperatures, and slower wetting rates may require the use of a wave flux chemistry designed for Pb-Free.

Some considerations are:

- Evaluation of higher solids no-clean formulations may be required.
- Slower wetting rates of Pb-Free alloys may require an alternative wave flux.
- Evaluation of water-soluble flux chemistries may be required to resolve soldering and cleaning issues.

Solder Alloy

High tin alloys (containing elements other than lead) may require elevated processing temperatures. Sn/Ag/Cu (SAC) and Sn/Cu alloys offer a viable alternative for Pb-Free wave soldering. You should fully evaluate any new soldering processes before implementation.

- Solder temperatures for Pb-free wave soldering are typically 260-270°C (500-518°F).
- The higher soldering temperatures of Pb-Free could damage components, warp the boards or stress solder mask and board finish.
- Fully evaluate new soldering processes before implementation.

Equipment Upgrades

The solder pot, solder pump, and other internal components that come into contact with the solder must be compatible with Pb-Free alloys. Pb-Free alloys can quickly dissolve stainless steel solder pots. It is important to remember that solder pots used for Sn/Pb should not be used for Pb-Free assembly without a tin wash process.

Locations Worldwide

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- **Metals & Specialty Chemicals**
- **Metal Thermal Interface Materials**
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