NO-RESIDUE TECHNOLOGY
CHEMISTRY AND PHYSICS

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Abstract

The main goal of this paper is to highlight the importance of interrelating the physics and the chemistry in wave soldering and soft soldering in general. Often we find the disciplines of chemistry and physics being analyzed distinct and separate. However in the quest for alternative ways for leading edge competitive and especially environmental friendly manufacturing, separating or ignoring this interrelationship is detrimental to the success of No-Residue soldering. Additionally the restrictions on chemistries under environmental impulse and the failures and limitations of flux-less soldering, should send us a message for the need of more basic understanding of what exactly is required to make a reliable solder joint and which forces are vital to assure process consistency, reliability and economy.

Introduction

It is not reasonable to assume that by changing to another flux in your soldering machine you can solve all the problems related to cleaning. It is unfortunately not as simple as that. The characteristics of a flux is a very important parameter but can only be successful when the machine parameters are adapted to the flux characteristics so we talk about a new soldering concept. The motivation for the electronic industry to make changes in the machine concept has been the change in quality management. With the goal to eliminate all corrective actions such as cleaning, it has also brought new product flow options; e.g. in-line processing resulting in process flow reduction, lead-time reduction and more process flexibility.

No-Residue Technology

Basic flux requirements

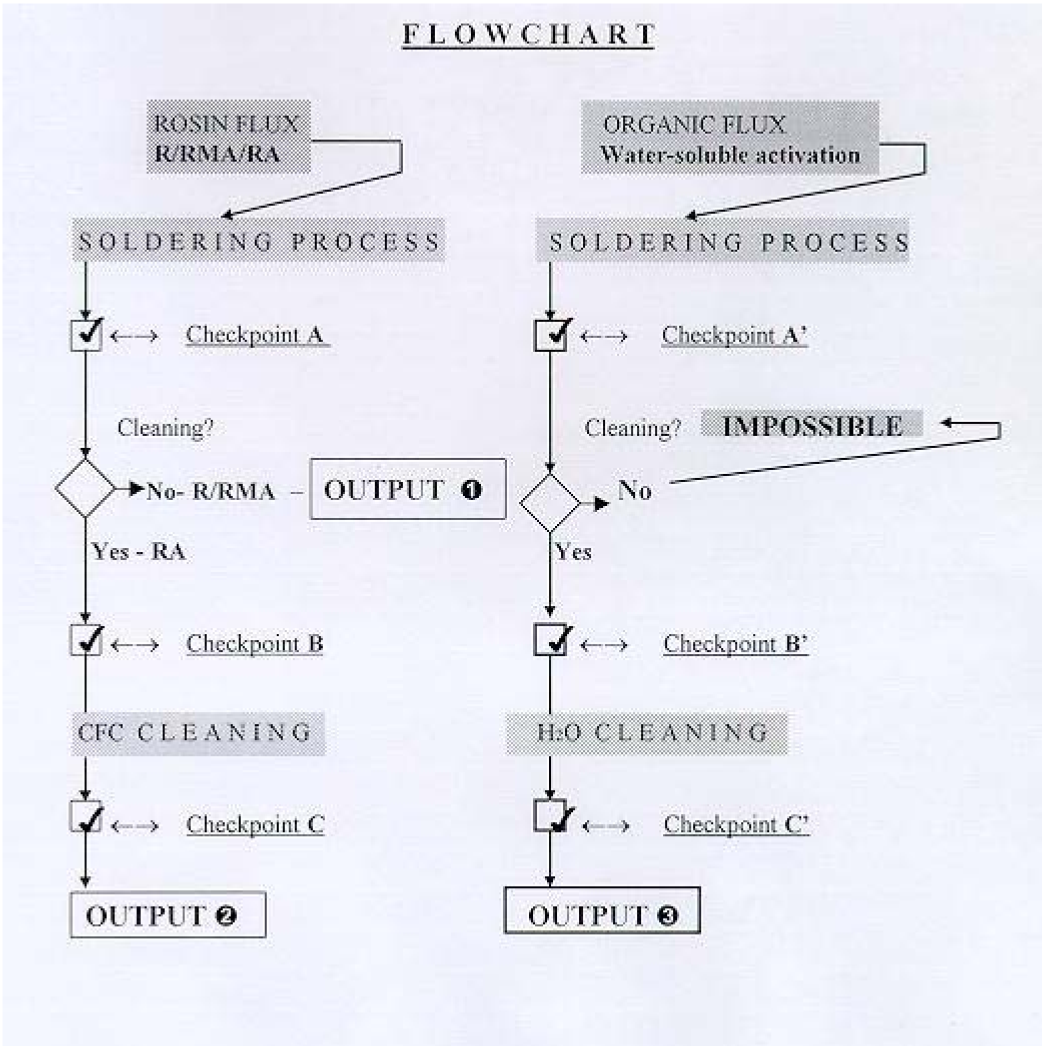
To have a better understanding of what exactly has to be changed in the soldering concept, we have to go back to some basic requirements needed to get a good solder joint. Basically we need two reactive metals. From the PCB- and component side, oxide-free copper and from the machine side oxide free tin. Copper an tin have the ideal molecular structure to be combined except when the metals contain oxides, because then the structure has a form of saturation.
The main challenge in soldering is the presence of oxides. The negative characteristics of oxides are: mechanical and chemical barrier, insulator and they are uncontrollable.
Oxides are not only formed in a soldering machine by the oxygen/heat combination because then an inert machine environment with nitrogen would be the ultimate solution. A manufacturing process has quite a number of other oxide sources e.g. storage, handling, heat processes such as oven curing PTH PWBs, reflow of SMDs and curing of SMD adhesives. A good oxide-reducing product is still required to eliminate previous process created oxides. the flux has to deoxidize the metals on the PWBs, the components and the solder wave. The flux also needs to protect the surface (base material FR4 or other) because you want to have solder on the solder joints and not on the base materials. Another function is to support and promote soldering forces such as wetting and capillary force.

Flux History

The existing flux types in order of development are: rosin fluxes, organic fluxes (water-soluble), low-solid rosin/resin based fluxes, "No-Residue" flux (rosin/resin free). The latter product still has to be separated because it still has no official classification although they have been used successfully for many years.

No-Residue Philosophy

To get a better picture on how we came to the No-Residue Philosophy or the way of thinking in No-Residue, I want to compare the rosin flux flowchart with the organic flux flowchart and the resulting No-Residue idea.

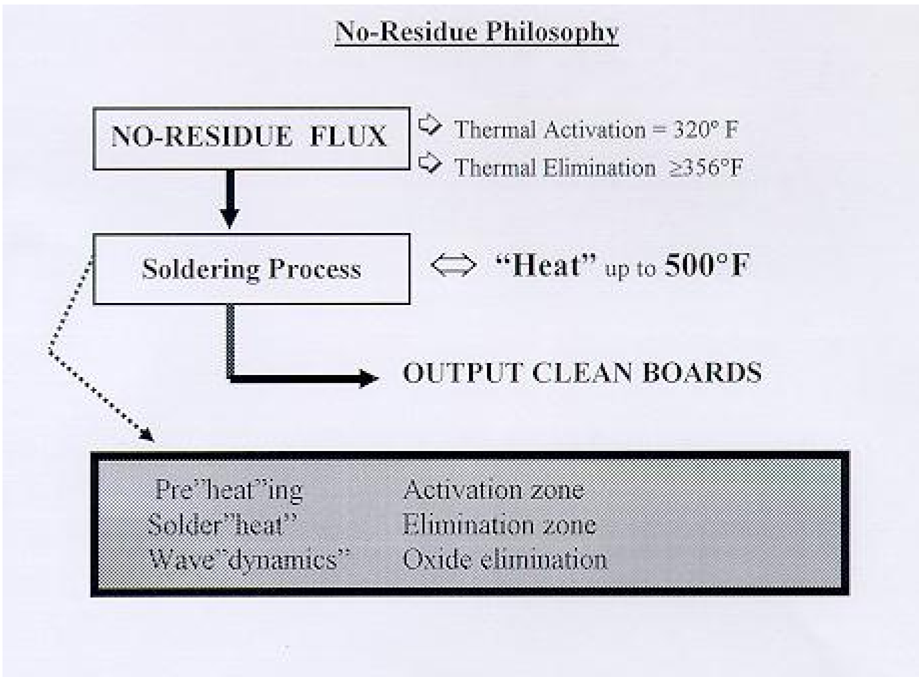


Checkpoint A: **(Rosin flux)**	- No remarkable changes in physical characteristics of the flux - Rosins contain oxides
Checkpoint A': **(Organic Flux)**	- No remarkable changes in physical characteristics of the flux - Flux bodies contain oxides
Checkpoint B: **(Rosin flux)**	- CFC problem - corrective action (cleaning)
Checkpoint B': **(Organic Flux)**	- CFC solution - corrective action (cleaning)
Checkpoints C & C':	- 98% of flux is eliminated - 2% flux is left on places where solder closed the access (under components)

OUTPUT 1 No efficient in-circuit testing possible, sticky boards and potential problems with contact pins on component side due to the capillary properties of rosins which are known to be good insulators

OUTPUT 2 Potential contact problems on places where cleaning solvents had no access

OUTPUT 3 Organic fluxes are known for their corrosive nature. the 2% hidden undetectable flux residues (if the sophisticated cleaning equipment couldn't remove them, an ionograph can't detect them) can result in serious reliability issues. The back-up for previous statement is that organic fluxes and water cleaning could not pass Mill approval. the IPC-B-36 pattern characterized by the SIR pattern under a SMT component proves this theory by failure on previous with water-soluble chemistry



Essential characteristics for a reliable No-Residue chemistry

- Application flexibility
- Thermal activation and elimination trigger
- Rosin/resin free
- Halide free
- Potential residues can not be water-soluble or ionic
- Proven reliable chemistry/technology (history, test data, references, approvals)
- Compatible with other chemistries (OSP, solder paste and solder wire)

NO-RESIDUE MACHINE CONCEPT

1. Foam fluxing

Foam fluxers are still the most used fluxer systems because of their simplicity. It only requires two parameters to check for reproducible results, air pressure and flux level. Unfortunately most foam fluxers are designed for rosin fluxes, so a few changes have to be made on the flux unit to perform well with a No-Residue flux.

- Make sure that the flux-nozzle opening does not exceed 0.4 inch.
- Foam contact with the board must not exceed 0.8 inch, this can be adjusted by reducing the width of the foam blockers or by removing them.
- Use high-density air stones. They give a high density stable foam. Air stones or baffles of 2 inch diameter and 20µ pore size are ideal.
- Air pressure 2 to 3 bar (150-200 psi), with 25 to 50 L/min volume depending on the height and length of the foam nozzle, is required.
- Flux level ± 1.2 inch higher then the topside of the air stone.
- Adjust the flux station to create kiss fluxing. This set-up avoids flooding of flux on the component side and eliminates the possibility of residues on topside.
- Never adjust the air pressure to establish kiss fluxing, raise or lower the whole flux station to achieve the right contact.
- Never use a foam fluxer without an air knife or alternative system to remove excess flux.

2. Air knife set-up for No-Residue soldering

- Use the air knife to avoid flux drops because these change the evaporation speed of the flux solvents and create flux concentrations due to the mass/gravity forces.
- The ideal blow angle of the air knife is 10 degrees, reverse to the traveling direction of the boards.
- The distance between the air knife and the foam nozzle must be minimum 4 inches to avoid blowing into the foam head.
- The distance between the air knife and the boards ± 1½ inch.
- The air pressure must be adjusted in such way that the flux drops are removed without pushing them through the holes onto the top side of the boards.
- The ideal air knife has a tube diameter of 0.5 inch, a hole diameter of ± 0.04 inch and an axial distance between the holes of 0.25 inch. Never allow the sum of the hole diameters to be larger than the air input diameter.
- Always try to get the excess flux back into the flux station (to eliminate the possibility of droplets around the flux unit).

3. Spray fluxing

Spray fluxing can be considered as the future fluxing technique. The development of the spray fluxer went parallel with the development of low solid (low rosin content) fluxes. The major advantages are:

- the possibility of dosing
- there is no physical contact between PWB and flux

The latter is definitely a major advantage in the No-Residue technology. For successful spray fluxing with a rotating drum, it is necessary to change the air knife angle from 30° reverse to the board's traveling direction (standard set-up) to vertical ± 1°. The reason for that set-up is to avoid shadowing effect on SMT components (mounted on the solder side) and to improve the flux wetting in PT-holes. Negative point on spray fluxers is that spraying in a heated environment increases the fire danger. To overcome that problem, most of the soldering machine and/or spray-fluxer manufacturers have built their spraying systems as a separate unit. Generally spoken, spray fluxers look more attractive than foam fluxers because of their sophistication but this usually results in larger amounts of process controls and or process variables. A foam fluxer has two parameters to worry about and the average spray fluxer has about 10. The experience so far made with spray fluxers clearly states that the paint nozzle types with compressed air, preferably pulsating, produced the most reliable and consistent results.

4. Preheating recommendations

This is a very important parameter in No-Residue soldering because it is the activation and reaction zone. With the use of the right heat curve you are able to optimize the flux performance. the ideal heating curve for a No-Residue flux needs to be progressive in energy (linear profile). The first (low) energy stage allows the different solvents to disappear sequentially without boiling them up to component side. The second (high) energy zone will optimize the activity and reactivity of the thermal triggered activation. A forced convention preheating is very effective in solvent evaporation and combined with medium or long wave IR will activate all the required physiochemical energy to assure optimum performance of a No-Residue flux.

Parameters: 212°F component side for conventional insertion

266°F component side for SMD applications (mixed technology)

These temperatures are measured on topside of the board before entering the wave

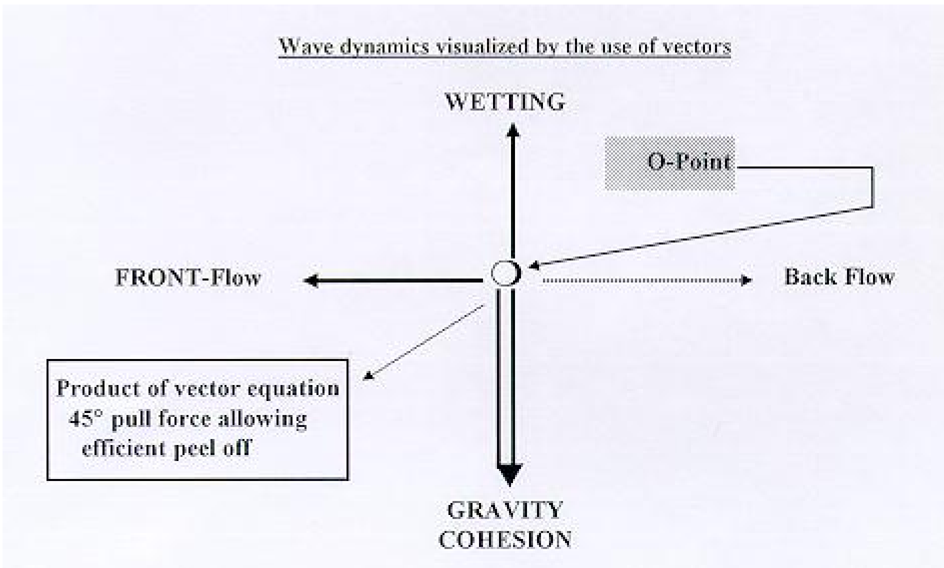
5. Wave set-up for clean and oxide-free boards.

As mentioned in the previous flux flowcharts, the oxides resulting from the flux-cleaning effect were from the organic and rosin fluxes encapsulated in the flux bodies. No-Residue flux does not contain any of these bodies, so the oxides have to be eliminated in another way. therefore we are using the wave dynamics to eliminate the oxides and also to optimize soldering performance.

Procedure

Bring a heat-resistant glass plate over the wave. With this action the oxides on the wave surface start to flow, reverse to the traveling direction of the glass plate. When you stop the glass plate over the wave, the oxides must stop flowing, then the board exit **0-point** is reached. This will optimize the solder peel-off and the draining of the wave surface oxides. Again, this physical intervention will have a significant impact on performance, reliability and quality of No-Residue soldering.

Dwell time must be al least 4 seconds to obtain the right heat transfer to the topside of the board. In order to volatize the potential excess flux, you need a relative strong wave front flow pressure and the board near complete thickness immersed without blocking the wave flow. Because in No-Residue soldering the conduction heat produced by the wave is used to force sufficient energy into the board to volatize all excess flux off the board. This set-up usually brings the fear for solder overflow on topside of the board, but if the wave dynamics are properly balanced the overpressure is released on the backside of the wave. The ideal No-Residue wave is a "asymmetrical double flowing wave with a powerful front flow and 0-point adjustment".



Conclusion

"NO-RESIDUE" is a process that can be successful if everyone involved in the process is properly trained and the process is properly controlled. As you all know, when major changes are made in a production process, all boards are inspected with more attention then before. Problems that were even present before the changes and which have nothing to do with the soldering process are discussed. Teamwork between the flux supplier, machine manufacturer and the Electronic Industry (yourself) are essential and the output will speak for itself.

References: None. This is a technology built on experience focused on problem solving and weakness of conventional processes. Oriented towards efficiency and environmental awareness and maybe most important **'it works!'**