TO CLEAN OR NOT TO CLEAN – BOTH SIDES OF THE STORY

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ABSTRACT

The electronics OEM's and EMS providers are faced with a choice when it comes to the PCB assembly process – A No Clean Process or A Cleaning Process. There are many factors that come into play when this choice is made, what complicates the choice are 2 key drivers. The first driver is the increasing pressure to reduce the cost to build the assemblies and the second is the need to build increasingly complex PCB's that are potentially going into harsh environments. The fact remains that there is a choice and how one goes about deciding what is right choice for your assemblies involves looking at a number issues and making an educated decision. This paper looks at all the factors that go into making the choice.

Key Words: PCB Cleaning Process, PCB Reliability, No Clean Process

INTRODUCTION

The electronics assembly industry has evolved over the years and turned predominately to a No Clean Process to the point where over 90% of all PCB's assembled in the world use a No Clean Process. For many years high reliability PCBs have utilized no clean technologies successfully in the telecom, automotive, industrial controls and computer industries. A No Clean process was chosen to reduce the cost per assembly, decrease cycle time and reduce material handling defects by eliminating the cleaning process. It also avoids the increasing costs of floor space, equipment, chemicals, water and electricity that are all required to run the cleaning process.

The early adopters of the No Clean process predominately used high rosin % liquid fluxes in the wave and traditional "RMA" Solder pastes with White Water Gum Rosin. This was the same approach that was adopted earlier by the Japanese Electronics Industry who to this day use high rosin content no clean fluxes in the wave and in the solder pastes. Rosin being the key element in ensuring that the residues would not be conductive or corrosive. Over time our industry has changed and so to have the requirements of the solder paste and wave soldering fluxes. We expect our soldering chemistries to still provide the same level of reliability but leave no visible residues while maintaining a high first pass yield. The challenge is to provide No Clean materials that satisfy today's process and reliability requirements have been met. Today's No-Clean solder paste and flux technology are more reliable based on new chemistries. The formulators have been able to blend high reliability rosins with activation systems that allow for Head in Pillow defect resistance for BGA's and increased solderability of LGA's and QFN's, IPC Class III voiding and residues that can be pin tested at ICT while maintaining high Surface Insulation Resistance (SIR). The rosins used are clear and depending upon the design of the PCB, are not visible. Specifically, the solder resist keep out areas around each pad will allow for the flux not to spread onto the resist becoming visible. It should be noted that these same No Clean Pastes that have been developed are being cleaned effectively in the state of the art cleaning machines with new chemistries used to effectively dissolve and rinse away the flux residues.

In order to come to an educated decision we must first understand the reasons for cleaning and how they apply to each situation. If not cleaning is the choice we must understand how we can ensure that reliability is built into each assembly.

REASONS TO CLEAN

There are a number of reasons that PCB's should be cleaned. They can be classified into two categories; PCB Functionality and Incompatibility with Downstream Processes.

PCB Functionality can be further broken down to Low Impedance Circuits, High Voltage Circuits and to a lesser degree RF Circuits. These reasons are all a function of the PCB design compatibility with the flux residues and can be tested for quite easily by testing for functionality in the environments that they will be used in. In all cases failures will be the results of the flux residue remaining preventing the circuit from functioning properly. Functionality does not guarantee Reliability. It is crucial for the test protocol to replicate the actual working environment so you are 100% confident that the assembly is reliable. Chemical suppliers test and report the reliability of their products to industry standards such as IPC, JIS and Bellcore which will not always meet the same heat and humidity requirements or voltage and SIR spacing requirements that are on your assembly. The lessons learned in this process can possibly lead to future designs that avoid the same issues where the failure took place. This is evident by the success that the RF Circuit designers have had with 5 -10GHz designs utilizing No Clean Processes.

Incompatibility with Downstream Processes can be such things as Conformal Coating Compatibility and Compatibility with Post SMT Processes.

Conformal Coating is generally used when a product is going to be operating in a harsh environment where good coating adhesion is required to ensure no liquids or gases can penetrate the coating leading to a failure. A consistent and thorough cleaning process prior to an even distribution of coating is the key to a successful coating process. While it is true that there are a number of OEM's that have been successful coating over No Clean Solder Paste and Wave Solder Fluxes the potential number of combinations of fluxes and coatings is staggering so full functionality and long term reliability testing should take place prior to coating over a No Clean process. There is a potential to actually reduce the SIR results by coating a No Clean Paste residue. In some cases the residues from the solder paste or wave soldering flux will not allow the coating to completely cure at the interface leading to adhesion and reliability issues.

Post SMT Processes can be such things as the solder paste being compatible with wave solder flux overspray and wire solder or rework fluxes.

THE NO CLEAN PROCESS – BUILDING RELIABILITY IN

The process of building reliability in starts with having a Process of Record (PoR) that is documented and regularly audited. The PoR starts with having a chemistry set that is compatible including the paste, flux, wire solder and touch up flux. Each step in the SMT and PTH process must then be measured and recorded. This is accomplished by having a solder paste printing process that is consistent and documented. The stencil design will dictate the volume of paste deposited and it can be measured a number of ways with semi or fully automated systems. The key is that any changes made to the stencil design once in production be kept on file. We can measure the reflow process by taking the thermal profile of each assembly when it is first introduced to production. It is recommended that a "profile board" be kept on hand to be used for future process audits to ensure the same profile is being used. The wave solder or selective soldering process can also be measured. The amount of flux applied is measured by weighing the actual amount of flux applied to the PCB using accurate scales. The pre-heat is measured by attaching thermocouples to the PCB or recording topside temperatures via lasers or temp stickers prior to the wave. The contact time at the wave can be measured by using a glass plate.

If hand soldering is required the operators should be trained to use only the cored wire solder with enough flux to promote fast wetting. In cases where components need to be replaced or rework/touch up is required that is not part of the documented PoR it is recommended that the flux residues be removed. This will avoid any question of long term reliability, providing you have a good manual cleaning process. There are fluxes that are designed for use in the touch up process that can be cleaned easily or when the left on the board after seeing a complete heat cycle will provide good SIR values.

Document the process and test for functionality and reliability of the assembly.

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CLEANING WATER SOLUBLE AND NO CLEAN CHEMISTRY

There are two main choices once you have decided that you are going to clean. They are Water Soluble or No Clean (includes Rosin containing fluxes). In both cases it is important to have a PoR documented as we have in the No Clean process and then we must also ensure that our cleaning process is consistent and measured. There are tools that can be used to test the cleaning process efficiency such as Ionic Contamination Testers for on site testing or more in depth analysis you can send out to an independent lab for detailed ion chromatography testing. With the introduction of low stand off components such as 0201, QFN, LGA, Bottom Termination Components (BTC's) and Micro BGA the challenge of cleaning is more dramatic and requires a combination of chemistry and cleaning power to yield clean boards. A thorough validation of the cleaning process is required for these low stand off components. In general the lower stand off parts require the solvent to flow under the part, this requires the solvent to have a low surface tension and the cleaning machine to provide a constant flow of water on the surface of the assembly. Water surface tension is lowered with the addition of a saponifier and is strongly recommended when cleaning fine pitch or low stand off parts with Water Soluble Fluxes. Dynamic cleaning or high pressure sprays will not always penetrate the smaller stand off heights in particular where there are adjacent components.

An additional consideration is the time between reflow and wave and the cleaning process. The water soluble residues because they remain active become more difficult to clean the longer they are left on the board.

When using a Water Soluble flux it is very important to know that if you plan to operate in an environment that has high heat and humidity you are at an increased risk of creating a short caused by electro-chemical migration with the exposed residue under tightly spaced components if you do not clean off all the flux residue. Test the PoR for functionality and reliability in the environment you will be operating. The same can be said to a lesser degree when you are cleaning a No Clean Solder Paste if you are only partially cleaning the residue and leave some weak organic acids exposed that were previously encapsulated in the rosin. Destructive tests such as removing the component to visually check for residues are not practical in a manufacturing environment but can be tested during process qualification or randomly during production.

PCB AND COMPONENT QUALITY

The quality and cleanliness of incoming PCB's and Components can have a direct impact on the quality of the assembly. It is incumbent upon the OEM or EMS provider to put procedures in place to measure the incoming quality. Depending on the products requirements for reliability and the complexity of the assembly the appropriate amount of resources should be spent on testing at incoming. The process of making PCB's and components uses a number of chemical processes that can leave unwanted residues that when not cleaned and subjected to harsh environments can lead to failures. Phosphates and halides are good examples of these.

CONCLUSION

The complexity of PCB design will continue to evolve leading designers to focus on functionality and reliability with no clean processes.

There will always be a need to clean ensuring that the cleaning equipment and cleaning solvent suppliers will continue to work together to clean more efficiently.

There will always be a choice to make; it just needs to the right choice for your assembly to ensure your customers keep coming back.