KYZEN

TECH 2 TECH Technical Article

Electronic Assembly Cleaning Basics – Manual Concentration Monitoring

Luis Fernando Gazcón
Mexico & Latin America

INTRODUCTION

It is a very interesting question, and to be able to answer it we would have to get inside a cleaning process to understand all the influencing factors.

First, we would need to understand the process dynamics ongoing inside a cleaning application. Take an inline spray cleaning process as an example, typically the wash tank will be filled with a specific proportion of DI water and a specialized cleaning agent. We refer to this proportion of water and cleaning agent as "concentration percentage."

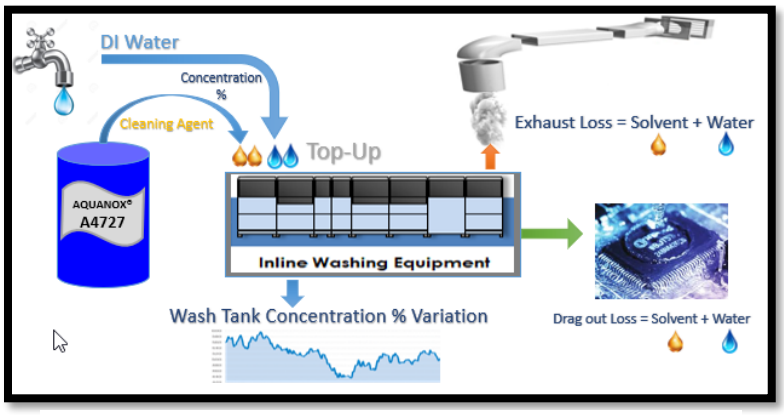


Figure 1. Basic Cleaning Process Dynamics.

WHY IS IT RECOMMENDED TO MONITOR THE CONCENTRATION PERCENTAGE IN CLEANING APPLICATIONS?

Let us use KYZEN's AQUANOX® A4727 as an example. According to the manufacturer KYZEN, the typical starting concentration recommended for a PCB Cleaning process is 10%. This means 10% of the wash tank volume of AQUANOX A4727 and 90% DI water.

When the PCB cleaning process starts running, a volume decrease in the wash tank level will be observed after an hour or less depending on the type of equipment. These liquid losses are caused mainly by 2 factors: exhaust and drag out.

Exhaust losses: Due to inherent washing equipment designs, when liquid is sprayed at high pressures inside the washer chamber, both chemical and water are continuously being pulled out by the exhaust system in the form of vapors and mist clouds generated.

Drag out losses: Trapped liquid on the substrate surface and cavities, as well as on the conveyor belt, are continuously carried to the next section of the washer.

Although they are small volumes of liquid lost, when added up with the operating hours of the

process, it will end up disturbing our original percentages of cleaning agent and DI water present in the tank inevitably changing the concentration percentage.

Percentages can be corrected by making water and chemistry additions periodically to keep the recommended concentration. Cleaning agent supplier should provide the recommended concentration percentage range for their cleaning chemistry [*Figure 2*]. It is imperative to follow this recommendation. Failing to do so would eventually have negative consequences in your process including the substrate cleaning quality and the overall cost of your operation.

If you are above the chemistry suppliers recommended percentage range, you could be facing some of the following issues:

Figure 2 Recommended Operating Concentration % Range

Poor Rinsing Capabilities:

- Your rinsing could no longer be enough to finish removing all chemical and flux residues. The higher your concentration, the higher rinsing is needed to achieve the desired results.

Material Compatibilities:

- A high concentration could cause material compatibility on sensitive metals or elastomers. The wash chemical could become more aggressive allowing it to attack the substrate surface. Some formulations may contain inhibitors to protect these types of materials, and when used at higher concentration, the product inhibitors become insufficient.

Faster Depletion of Your DI Filters:

- High chemical concentration will contaminate your rinse tanks at a faster rate than expected. This will impact your consumption of DI water resulting in a quicker depletion of your DI beds, especially if you are recirculating your rinse.

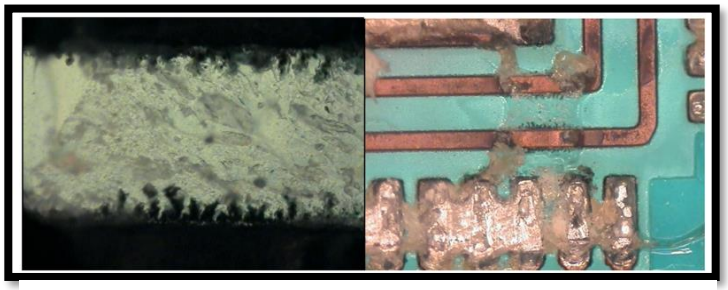


Figure 3 Ionic Flux left underneath electronic components.

Excessive Chemical Consumption:

- Higher chemical consumption will impact your overall process costs.

Conversely, operating at a lower concentration could have worse consequences. Lower concentration-percentage means that flux residues will not be completely removed during the cleaning process. These residues could be left under critical components. Due to their ionic content, they could eventually end up forming dendrites, resulting in intermittent or complete failures, resulting in shorts or leaks.

Device reliability would be compromised leading to warranty returns or unexpected reworks. This translates into a more costly process than the previous case.

HOW DOES CLEANING AGENT CONCENTRATION PERCENTAGE AFFECT THE CLEANING PERFORMANCE?

Engineers like to know the reasons behind everything. Therefore, we will have to go into how concentration can affect cleanliness results. One of the main reasons cleaning agents are required in these processes is their ability to decrease water surface tension.

Figure 4 Graphic explanation of: "Lowering Water Surface Tension"

Please refer to *Figure 4*. The top drop is just simple water, the bottom drop is a drop of water with an engineered cleaning agent. Cleaning agents allow water droplets to penetrate under critical low stand-off components, enabling it to get in direct contact with flux residues. This is critical to completely dissolve and remove the flux residues from the substrate surface.

An engineered cleaning agent basically flattens the droplets of the liquid, and as concentration percentage decreases, liquid droplets height increases.

Keeping concentration in the recommended range means maintaining the cleaning chemistries ability to penetrate and clean underneath all components and all spaces.

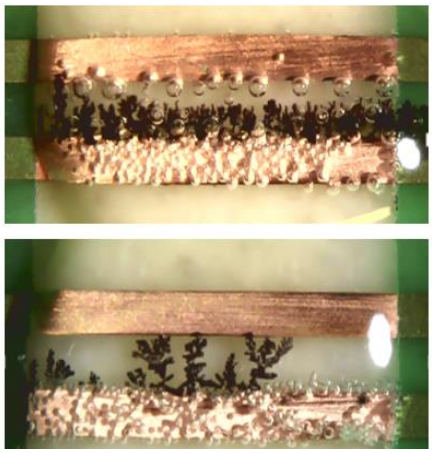


Figure 5 Dendritic Growth between 2 terminals underneath electronics

Figure 5 shows how ionic content on flux residues could react developing a phenomenon known as dendritic growth. For this phenomenon to occur you need three conditions. Humidity, temperature, and voltage, all combined with ionic residues left on wrong places could end up in shorts or current leaks.

To reduce the possibility of dendritic growth it is important to clean to the assigned cleanliness requirements. Once these process parameters are confirmed it is important to stay within those values.

IF IT CANNOT BE MEASURED, IT CANNOT BE CONTROLLED

Fortunately, there are reliable methods available, both manual and automated, to help measure cleaning agent concentration in a cleaning process.

The following are the 3 most common manual methods available for monitoring a PCB cleaning process:

- ✓ Split Measurement Method
- ✓ Refractive Index (where you will require a refractometer)
- ✓ Titration

To select the right method, first we must identify what is the nature of the chemical we will be using. Is it a hydrophobic splitting type chemical? Or Is it a hydrophilic homogeneous type of chemical?

Hydrophobic chemicals, also known as splitting type, when left static tend to separate and form layers. This is due to the different densities between their component's formulation. The other type, hydrophilic chemicals, form a homogeneous mixture when mixed with water and do not separate when left static.

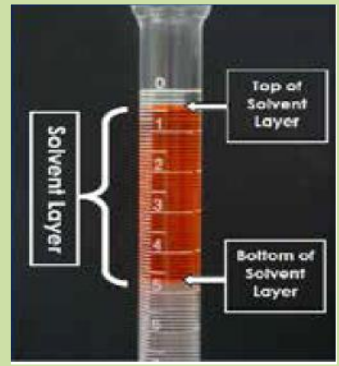


Figure 6 Solvent Phase Separation after Reagent interaction.

Split Measurement

Split measurement method is usually recommended for hydrophobic type of cleaning agents. It uses a separation characteristic, by measuring the proportion of solvent layer formed in the sample. This allows you to calculate the proportion of cleaning agent present in the mix.

For this method you will require:

- Sample of a well-mixed wash tank solution
- Instruction sheet
- Conversion charts
- Split kit with reagent

This method will take about 10-15 minutes to complete. Using the graduated flask included in the test kit involves adding a reagent powder and wash bath sample taken from your wash tank. The reagent will act as a catalyst accelerating and tinting the phase separation in a striking color for easy identification. After about 10 minutes a solvent phase separation should be complete, and the layers will then be visible. Using a graduated flask (included in the Split Kit) you will be able to measure the number of milliliters of the color separation layer formed. Utilizing the conversion charts provided by the manufacturer, you can transform the milliliters value obtained into a concentration reading.

mL	Concentration (%)
2.8	13.4
2.9	13.6
3.0	13.8
3.1	14.0
3.2	14.1
3.3	14.3
3.4	14.5
3.5	14.6
3.6	14.8
3.7	15.0

Figure 7 Example of mL to % Concentration Conversion Charts

Refractive Index

The Refractive Index method is best suitable for hydrophilic type of chemicals. Refraction works by passing light through a sample taken from the wash tank solution. A sample drop is placed on the refractometer prism. The device is designed to measure light beams refraction while passing through the drop and prism. This deviation is then measured precisely in a Brix° Scale printed on the prism [*Figure 8*].

Figure 8 Refractometer with Brix° scale.

Using a Brix° conversion chart offered by the chemical manufacturer, we can easily convert the Brix° value obtained by the refractometer into the concentration value.

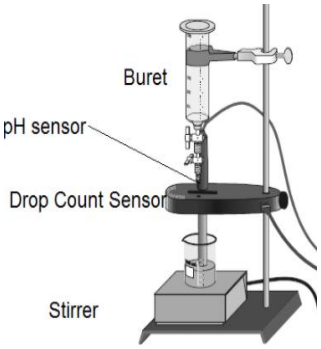
°Brix	%Conc
9.0	15.0
9.2	15.4
9.4	15.7
9.6	16.0
9.8	16.4
10.0	16.7
10.2	17.0

Figure 9 Example of Brix° to %

This method is one of the easiest and quickest to be perform, taking 1 to 2 minutes to complete. It is very important to state that this method uses a physical property of the liquid, and particles or solids floating or diluted in the solution could alter or deviate the measurement taken by the refractometer. Therefore, this method should be selected only if the conditions of your cleaning process allow it.

Titration

Titration is a method more suitable for Lab analysis due to the precision skills required. Although it is one of the most precise, it involves analyzing the sample using an indicator and a titrant. It can be used for either type of chemicals hydrophobic or hydrophilic.



The method involves getting a sample of the wash tank solution and diluting it into a known water volume specified in the instructions. An indicator solution is used to tint the diluted sample, which results in a chemical reaction with the formulation content. A titrant is then added into the sample drop by drop, making sure it mixes well until the color set by the indicator completely disappears.

It is very important to keep track of the total number of titrant drops required to eliminate the color. The number of drops will be converted into the concentration percentage value using the charts provided by the manufacturer. Titration is the most precise method from the options discussed since it involves chemically measuring the presence of certain components of the formula. It is sometimes not suitable for the production floor due to the more precision process.

Figure 10 Manual and Lab Titration Test Kit

WHAT YOU SHOULD TAKE BACK HOME

After all the information presented, we now understand that monitoring and controlling your cleaning process is crucial for maintaining the expected cleanliness results. Failing to control your cleaning agent process concentration percentage can have widespread and costly consequences for your process. It can also compromise the quality and reliability of your final product and inevitably increase your overall costs.

Of the manual monitoring methods available, the best is the one that fits the type of chemical being used. All of them are accurate from an operational standpoint, they just use different chemical and physical properties depending on the characteristics of the cleaning agent we are using.

- Split Method – hydrophobic cleaning agents
- Refractive Index –hydrophilic cleaning agents
- Titration – any type of cleaning agent

New semi-automated and fully automated monitoring methods are also available. They are offered by cleaning agent manufacturers, designed to continually monitor your wash chemistry process, and adjust of chemistry and water. This ensures a prompt reaction and a complete close loop automatic control system.