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Excess Fluxes and Defluxers: High Reliability Electronics Risk

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Abstract

The removal of solder flux residue from circuit board assemblies is crucial for high reliability, long life electronics. If flux is not fully removed post-solder, it can cause corrosion or act as a site for the accumulation of contamination, resulting in electrochemical migration failures and/or component damage. The flux cleaning agent (defluxer) can also cause unintended interactions if residue is left on the board. This study focuses on two cases of the effects of excess flux and defluxer: on circuit board materials at concentrations well over those seen in use (as a worst case scenario) while immersed in silicone oil at ambient temperature, and on Cu coupons with long/brief cleaning with hand soldering (as in rework) in warm, wet air. First case results show the most corrosion with Kester 2331-ZX and the least with Kester 185 flux, and the defluxers with the worst corrosion ratings are Aquanox A4241 and Vigon N600. D-Limonene cleaner results in the lowest ratings. Second case results indicate most/least corrosion after cleaning is seen with the same fluxes, but the worst damage risk cleaners are the vapor phase defluxers, Vertrel SDG, Precision V and AK225, and the least damage risk are Vigon N600 and DI water.

Introduction

The goal of the study is to determine which fluxes and cleaning agents pose the most or least risk of corrosion and damage to circuit boards and their assemblies.

The first case of this study is to test for corrosion or damage from excess fluxes and defluxers on both a vulnerable solder material, copper, and on other circuit board materials in the same enclosed environment. Each flux is individually combined with each defluxer and with other coupons in a silicone oil environment and aged. Adding a small amount of cured flux and cleaner will help determine which combinations are most damaging, presenting the higher risk in use.

In the second case the same fluxes and defluxers are used under typical hand soldering conditions. One sample of each flux/defluxer combination is treated with a long cleaning, another of each combination with a brief cleaning, then all coupons aged in room air, with heat and humidity to accelerate possible damage.

Visual inspection of coupons at the termination of four weeks aging allows comparison of damaging effects on the materials involved. Inspection includes signs of corrosion, staining, and pitting in all materials of the assembly.

Materials

The materials to be tested are used in electronic assemblies.

Solder Fluxes

- Kester 2331-ZX (water soluble liquid)
- Alpha NR330 (no-clean liq.)
- Kester 979 (no-clean liquid)
- Alpha WS809 (water soluble paste)
- Kester 185 RMA
- Kester 197 RMA

Cleaning Agents

- Deionized (DI) Water
- 200-proof Ethanol
- D-Limonene
- Aquanox A4241 (aqueous)
- Vigon N600 (aqueous)
- AK-225 (vapor)
- Precision V (vapor)
- Vertrel SDG (vapor)

Coupons

- Copper+
- Kovar
- Paliney #7
- Stainless Steel
- Torlon

+ oxygen free electronic grade Cu only, for Case 2

Methods

Metal coupons are prepared by clean in 10% Brulin at 40 kHz ultrasonics and 60 ^{O}C, and rinsed in DI water. The Cu is also treated with a 15 second acid dip. Torlon is cleaned with an alcohol rinse. Pre-exposure images were taken of all materials.

For Case 1 0.18 mL flux is added to the Cu coupons, which are placed on a hot plate at a temperature selected to mimic the typical soldering process. Coupons are grouped into high, 370 – 450 ^{O}C, and low, 230 – 280 ^{O}C, temperature sets. After cooling to ambient, all coupons are placed in glass jars for aging. The jars are filled with 6.0 mL silicone oil and 0.18 mL defluxer, gently agitated, covered, and stored at ambient temperature for 4 weeks.

Case 2 consists of Cu coupons with hand applied solder using the same fluxes. Half of the soldered coupons are treated to a brief 1 minute dip cleaning, with brief rinse (Clean B) and the other half a more thorough 3 – 5 minute soak, agitate and/or ultrasonics cleaning, with 3 minute rinse (Clean A). Ionic residue is measured with an Ionograph before coupons begin the 65 % humidity at 30 ^{O}C exposure for four weeks.

Coupons are inspected immediately upon removal, and again after cleaning steps to help remove gross contamination. A rating system was implemented to determine the comparative amount of residue and corrosion damage as well as the effort to clean. The number scale increases with the amount of residue or damage by corrosion. The rating reported for each jar is a sum of the ratings given by each material for Case 1, shown in Table 1. Case 2 uses the same type of rating scale as Case 1 for the pre and post clean observations as well as a scale based on Ionograph results. The rating reported for each coupon is the sum of all three ratings for Case 2, Tables 1-3.

KEY	Rating Description
0	no discoloration or pitting
1	very slight stain, no residue or pitting
2	visible stain, little residue, no pitting
3	visible stain and residue, slight pitting
4	heavy stain and residue, visible pitting
5	heavy stain, residue and pitting

Table 1: Case 1 and Case 2 Rating Guide – Post Clean

KEY	Micrograms of NaCl equivalent
0	<0
0.5	0-75
1	76-150
1.5	151-225
2	226-300
2.5	300+

Table 2: Case 2 Rating Guide – Ionograph

KEY	Rating Description
0	No Discoloration/Residue
0.5	Slight Discoloration/Residue
1	Discoloration/Res on <25%
1.5	Discoloration/Res on 25% to 50%
2	Discoloration/Res on 50% to 75%
2.5	Discoloration/Res on >75%

Table 3: Case 2 Rating Guide – Pre Clean

Results

Figures 1 - 4 show samples for the best and worst rated fluxes and cleaning agents for each temperature group for Case 1; fluxes are in Red and defluxers in Blue. Rating results are plotted for easy comparison in Figures 9 and 10.

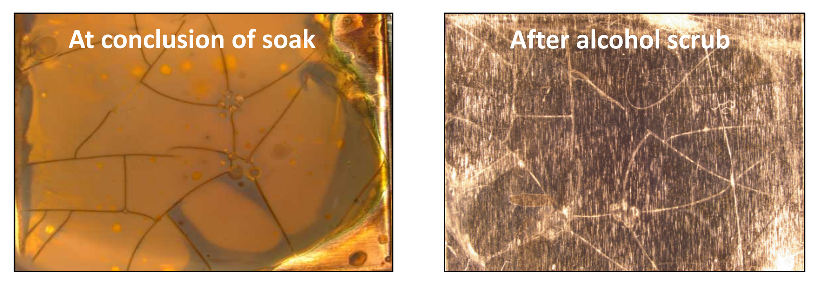


Figure 1: Case 1 Best of Low Temp; Kester 197 RMA, DI Water

Figure 2: Case 1 Best of High Temp ; Alpha NR330, Precision V

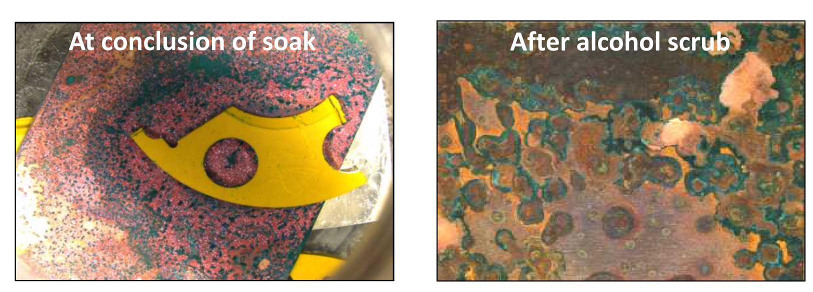


Figure 3: Case 1 Worst of Low Temp; Alpha NR330, Vigon N600

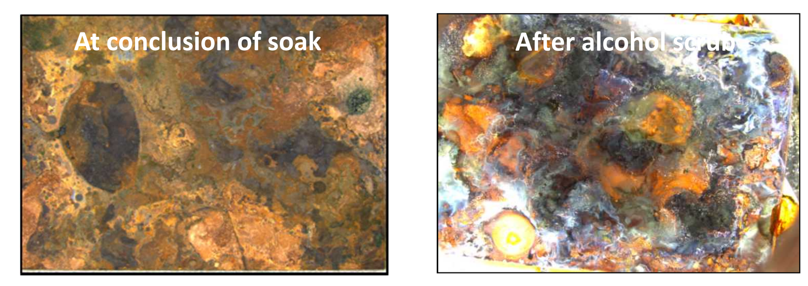


Figure 4: Case 1 Worst of High Temp; Kester 2331-ZX , Vigon N600

Figures 5 – 8 show samples for the best and worst rated fluxes and cleaning agents for each cleaning type in Case 2; fluxes are in Red and defluxers in Blue. Rating results are plotted for easy comparison in Figures 11 – 13.

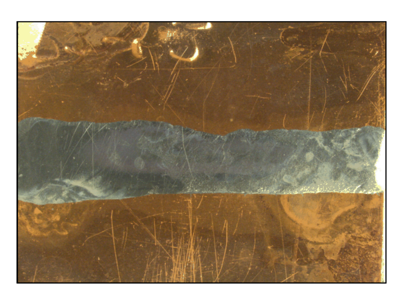


Figure 5: Case 2 Clean A, best 185 RMA, Vigon N600

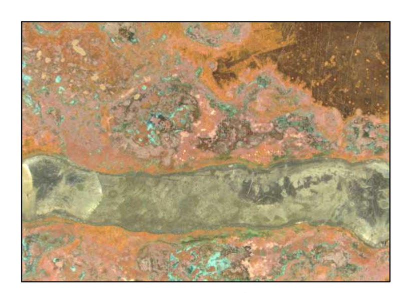


Figure 6: Case 2 Clean A, worst Kester 2331-ZX, Vertrel SDG

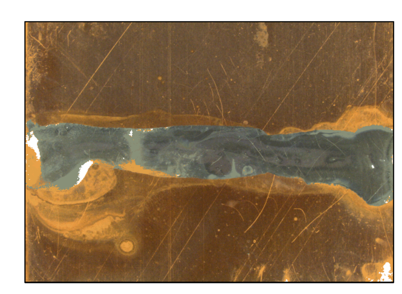


Figure 7: Case 2 Clean B, best 185 RMA, DI water

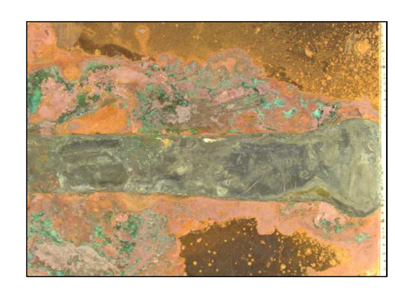


Figure 8: Case 2 Clean B , worst Kester 2331-ZX, AK-225

Figure 9: High Temperature, Corrosion Rating

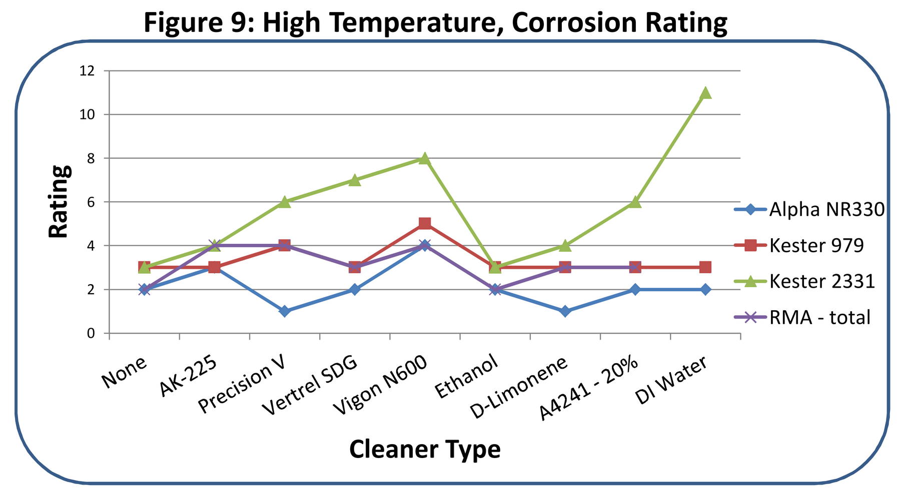


Figure 10: Low Temperature, Corrosion Rating

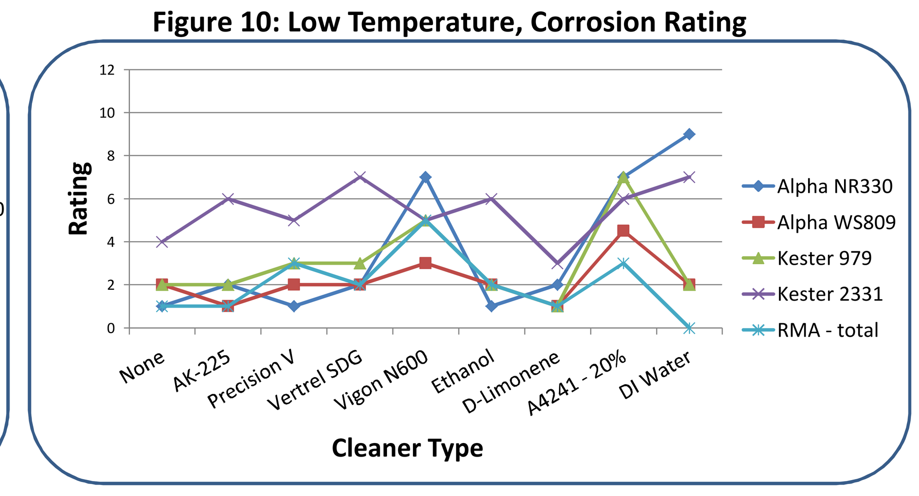


Figure 11: Clean A, Corrosion Rating

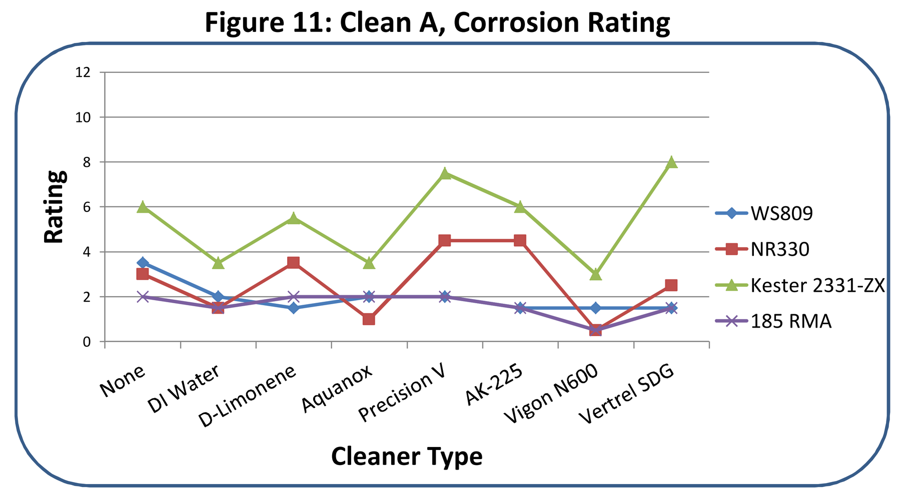
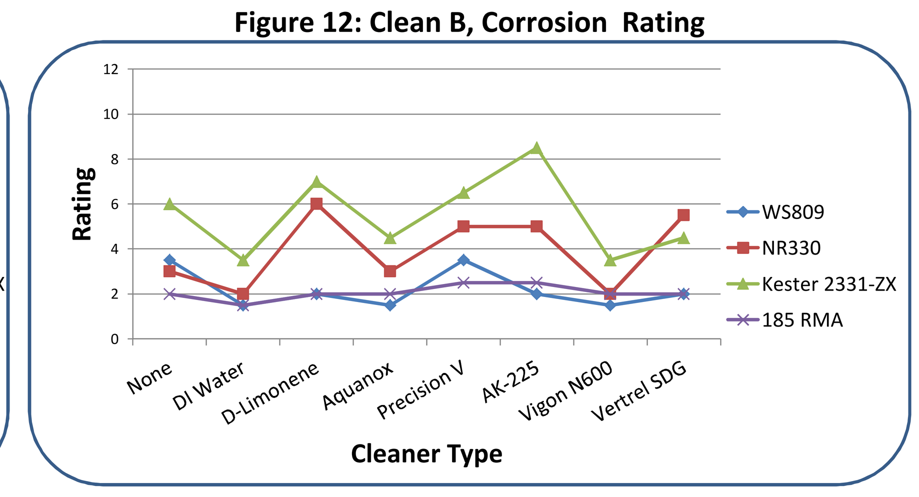


Figure 12: Clean B, Corrosion Rating

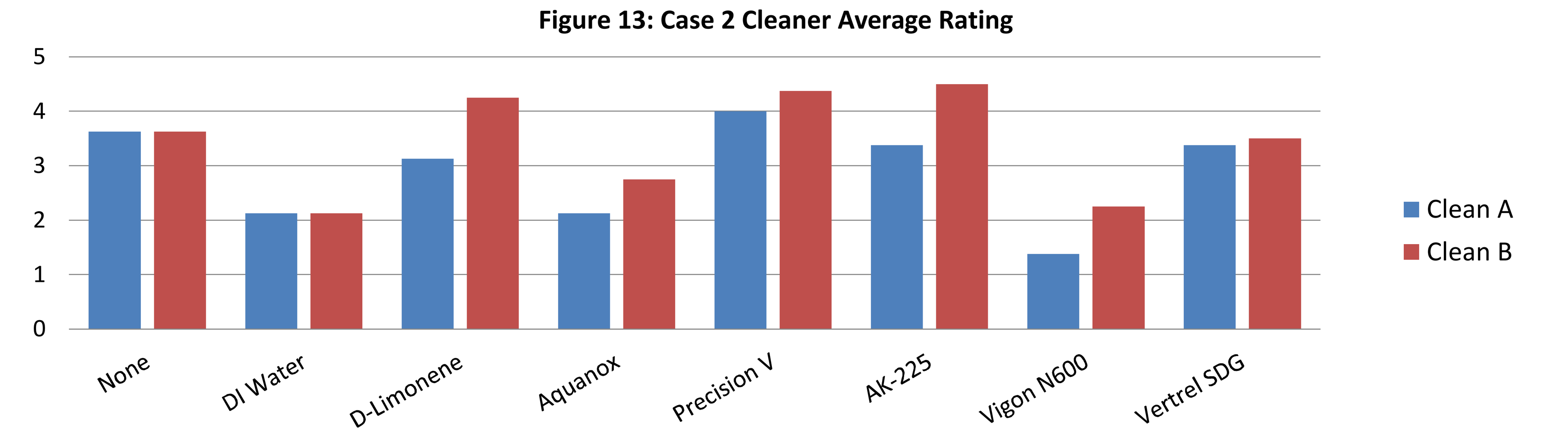


Conclusions and Discussion

In Case 1, where no removal of flux or rinsing of defluxer was attempted, the most corrosion appeared with Aquanox 4241 and Vigon N600. In Case 2, when cleaning with rinsing, most corrosion occurred with the vapor defluxers. The performance of the vapor defluxers in Case 2 may be due to lack of physical pre-clean, or insufficient time spent in the vapor. The poor performance of the aqueous defluxers in Case 1 may be due to insufficient or no rinsing. Further study of cleaning efficacy and determining optimal clean/rinse time and method will be the third case in this study of fluxes and flux cleaning agents. The results of these first two cases demonstrate the need for appropriate cleaning and rinsing to achieve low corrosion risk.

It is noted that all coupons in Case 1 were exposed simultaneously to each solution, thus it is possible that galvanic corrosion accelerated or decelerated coupon damage.

Figure 13: Case 2 Cleaner Average Rating



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