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THE BEST WAY TO Clean Water-Soluble Fluxes

SOLDER PASTES USING ROSIN-BASED FLUXES HAVE BEEN THE INDUSTRY STANDARD. THE NEED NOW IS TO ESTABLISH PARAMETERS FOR ASSEMBLY METHODS THAT DO NOT DEPEND ON CFCS FOR CLEANING.

By Rick Roney

One logical approach to eliminating chlorofluorocarbons is to use water-soluble solder pastes. For years, electronic assembly houses have used aqueous cleaning for removing the water-soluble fluxes of the wave soldering operation. In fact, aqueous cleaning of assemblies has been studied and characterized extensively. Obviously, a "drop-in" solder paste that could be cleaned in the same aqueous cleaner would eliminate many of the headaches associated with qualifying an entirely new cleaning process. The questions then become: 1) Can water-soluble solder pastes be used as "drop-in" replacements for rosin-based materials, thereby requiring little or no changes to the basic process? and 2) Can we use the same cleaning requirements and parameters? Since the second question seems to pose the larger challenge, it is approached first.

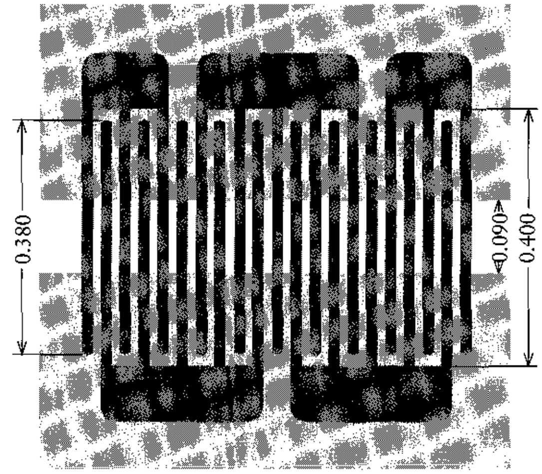


Figure 1. Modified (Bellcore) SIR pattern/windowed version. Cross-shaded area is soldermasked. Conductors are 0.400" by 0.012" wide; spacing: 0.025". Unconnected ends of conductors are radiused (length of conductor overlap: 0.380").

Aqueous Cleaning Philosophy

The current philosophy is based on cleaning very active water-soluble fluxes from assemblies featuring both plated through-hole components and SMDs. The process was set up after extensive experimentation to determine what combination of equipment and parameters was required to remove flux from under all parts. With the proper clearances it was felt that all flux residues of the water-soluble pastes could be removed. And subsequent testing proved this to be true. Thus, the biggest concern was to determine the effect of not cleaning and/or the consequences of delayed cleaning.

Obviously, with a very active flux (of the type used for wave soldering) omitting or delaying cleaning can be detrimental to performance and reliability. Prior testing had shown that these fluxes must be removed within 30 min after soldering to prevent their corrosive action. Hence, the concern centered on meeting the time requirement without adding another cleaning process.

SIR Testing

A test to determine the effect of omitted (or delayed) cleaning of water-soluble paste residues is based on surface insulation resistance (SIR) measurements of the cards. The equipment used is a "SIRometer"* and a temperature and humidity chamber. Relative humidity in the chamber is maintained at 90 percent at a temperature of 35°C. Test bias voltage is 48 V with a testing voltage of 100 V. Duration in the oven is 24 hours plus the additional time required for data recording.

The SIR pattern used is a modified (windowed) version of the Bellcore[1] pattern as shown in figure 1. Two patterns per board are tested — one pasted and one unpasted (control). The boards are precleaned in the standard aqueous cleaner with heated deionized water.

Four solder pastes are tested and are referred to as pastes A, B, C and D. The stencil used to print the solder paste is 0.006" thick stainless steel. Two boards per solder paste are tested for each process possibility.

The cleaning procedures established to simulate typical and worst-case possibilities are performed on eight boards per process and are summarized as follows:

1. Reflowed, not cleaned, tested immediately
2. Reflowed, 72-hr hold before cleaning, tested immediately
3. Reflowed, 168-hr hold before cleaning, tested immediately
4. Reflowed, cleaned immediately, tested immediately
5. Reflowed, cleaned immediately, tested after 24-hr hold
6. Reflowed, cleaned immediately, tested after 48-hr hold
7. Reflowed, cleaned immediately, tested after 168-hr hold

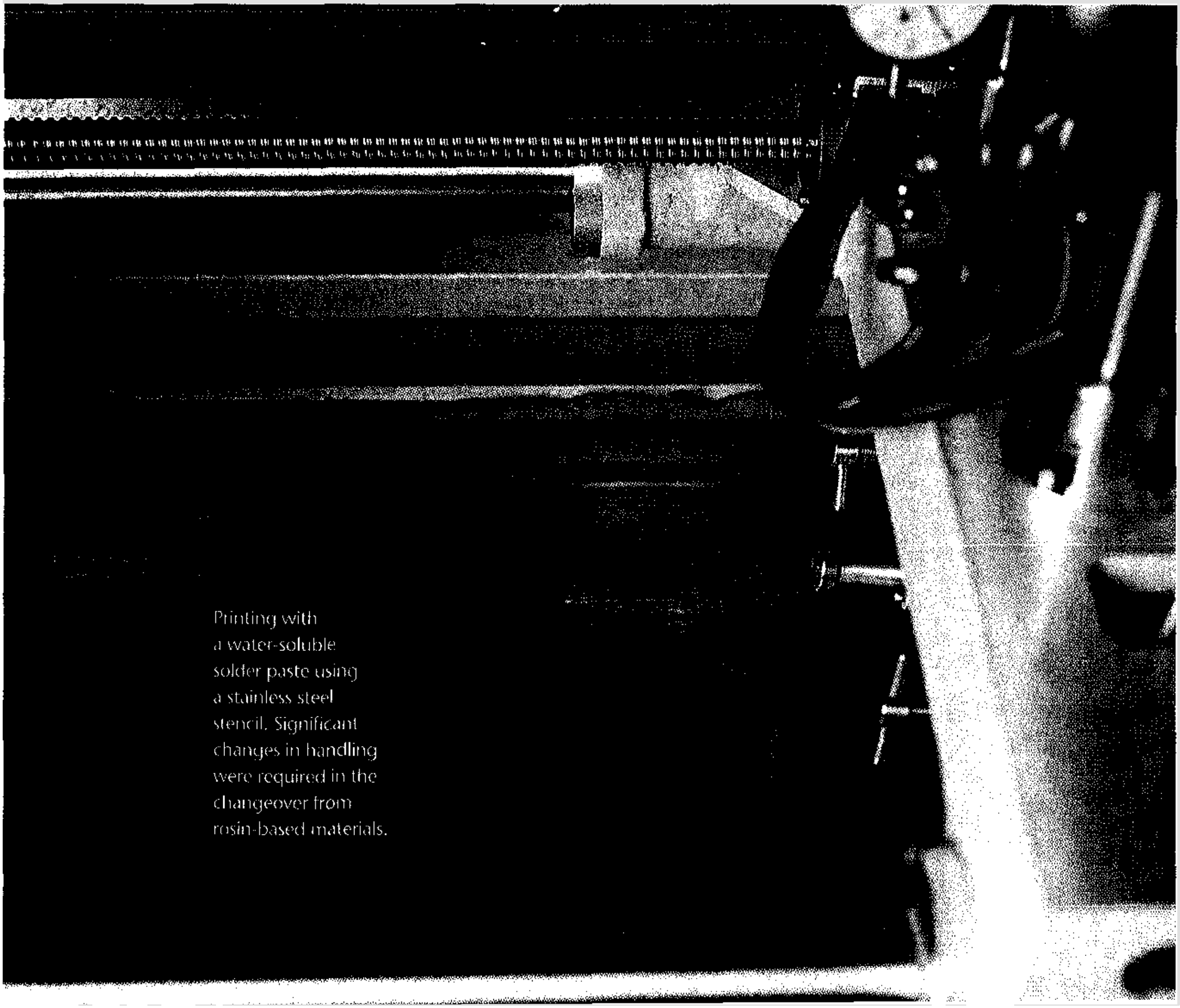
The testing procedure for each board:

A. Preclean.
B. Stencil print the appropriate solder paste to a measured height of 0.0045 to 0.0075".
C. Reflow the paste in an IR/convection oven using an appropriate reflow profile as defined by the paste manufacturer.
D. Clean the board in the standard aqueous cleaner at the proper time interval as defined by the above procedures.
E. Test the resistance at the time interval listed. The SIR testing procedure is defined by Bellcore document TR-NWT-00078[1].

Results

Results of the SIR testing are shown in figures 2 through 4. The average SIR value for each solder paste is plotted on the appropriate chart for three process possibilities. If the lower average limit is set at $3.0 \times 10^9\ \Omega$, it can be seen that, in all cases except the no-clean possibility, the readings for all four solder pastes are well above the lower limit. In the case of the no-clean possibility (figure 2), all four solder pastes display SIR values that are well below the (Bellcore) lower limit.

Results indicate that a delay as long as 72 to 168 hours (one week) between reflow and cleaning of water-soluble solder pastes will not significantly affect the surface insulation resistance of the board, rendering cleaning immediately after reflow as unnecessary. Also, while a single cleaning after wave solder should be adequate, abstaining or



Printing with a water-soluble solder paste using a stainless steel stencil. Significant changes in handling were required in the changeover from rosin-based materials.

incomplete cleaning is clearly detrimental to SIR results. The process must be monitored and controlled to ensure this does not occur.

With these results, one can feel confident, from a cleaning standpoint, of eliminating solvent-type cleaners from the assembly line. Also, a good understanding of what monitors and controls would be needed to establish reliable aqueous cleaning of water-soluble pastes was obtained.

Changes During Processing

Using the results of the SIR testing, the two solder pastes with the highest SIR readings (Paste A and Paste B) were selected to evaluate in the "front-end" processes (stencil print and reflow). Preliminary characteristics were established, including viscosity, solder balling tendency and metal content to ensure that the pastes were suitable for processing and to determine how their characteristics change during processing.

After several weeks of production testing, only slight differences were found between the two pastes as far as processing characteristics were concerned. Paste A seemed to wet slightly better to all types of PCB surfaces, indicating that it might contain a more active flux than Paste B. (Paste B SIR values were higher, in most cases, than those of Paste A.)

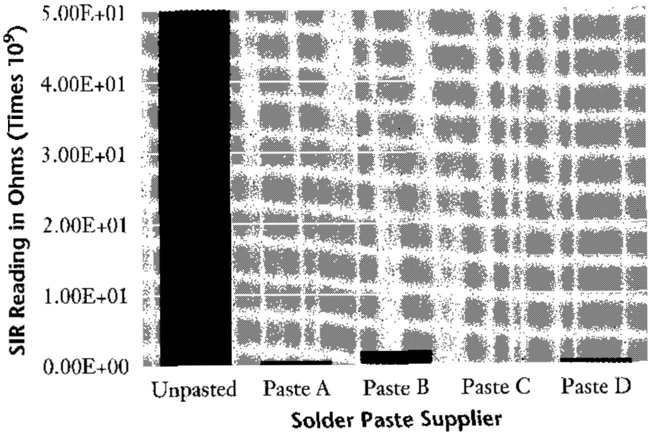


Figure 2. SIR results for pastes reflowed, not cleaned, and tested immediately. In this case, all four pastes are below the lower limit.

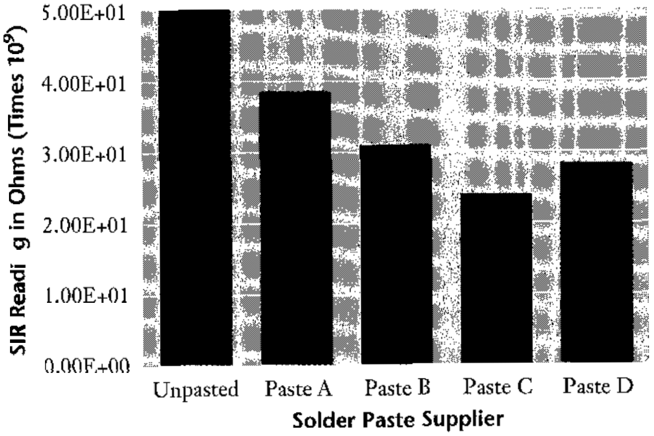


Figure 3. SIR results for pastes reflowed, followed by 72-hr hold before cleaning, then immediately tested. Note all pastes are well above the lower limit.

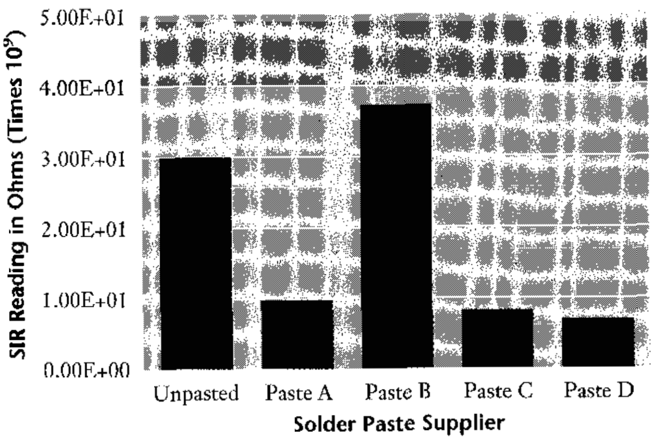


Figure 4. SIR results for pastes reflowed, followed by immediate cleaning and testing.

However, significant differences were noted between the processing characteristics of the water-soluble pastes compared to those of the rosin-based materials used previously. The water-solubles proved to be much more sensitive to variations in humidity, both high and low. Also, they had much shorter tack lives than those of the rosin-based pastes, which, in any case, may be deceiving and dependent only on which pastes are compared.

Significant differences were noted in the required reflow profiles for the water-soluble solder pastes as compared to those for the rosin-based. The water-solubles performed better without any preheat dwell, using a fast, direct ramp to soak temperatures. Increased peak temperatures (as high as 225° to 235°C) were beneficial when they could be attained without compromising the electrical components on the board.

Basic characteristics such as metal content, solder balling tendencies, required printed thickness and print definition were the same as those for rosin-based paste. Differences in cleaning requirements have already been noted.

Conclusion

As a result of efforts to eliminate the need for CFC cleaning, a conversion to aqueous cleaning using water-soluble solder pastes has been effected. Preliminary and production testing show that water-soluble pastes cannot be considered as "drop-in" replacements for the rosin-based types, and changes to the preliminary processes are required to ensure a successful transition.

Results of SIR testing were used to establish cleaning requirements. They showed that the process required should be similar, but less stringent, than that for water-soluble fluxes commonly used for wave soldering. The author thanks Laurie Porter, Craig Addis, George Belokas and David Throop for their assistance in preparing this article. SMT

References

1 Bellcore TR-NWT-000078, *Generic Physical Design Requirements for Telecommunications Products and Equipment*, December 1991.

* Alpha Metals, Inc., Jersey City, N.J.

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