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Supporting Data and Numerical Examples for ANSI/J-STD-001B: APPENDIX D (Control of Fluxes)

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Supporting Data and Numerical Examples for ANSI/J-STD-001B: Appendix D (Control of Fluxes)

A study by the Solder Process Compatibility Test Vehicle and Methods
Task Group (5-22g) and the Soldering Subcommittee (5-22) of IPC

Users of this standard are encouraged to participate in the
development of future revisions.

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Supporting Data and Numerical Examples for ANSI/ J-STD-001B: Appendix D (Control of Fluxes)

Foreword

The purpose of this white paper is to document some of the technical rationale and additional data that a potential user of the revised Appendix D might find useful. In order to try to preserve the original “flavor” of the comments/discussion, this document is broken into sections coinciding with the proposed revision to Appendix D and rationale given in each section.

1 SCOPE/INTRODUCTION

1.1 Scope During the kickoff meeting at San Diego for this task group (5/1/95), a vote was taken to determine if the attendees (some 26 members of industry) felt that a revision to the existing appendix D was needed. The group voted unanimously that a revision was required. The two major areas of complaint were: a) there were concerns regarding the lack of a “uniform” approach made the testing more costly and delayed implementation for both users and suppliers; and b) the test method didn’t address all assembly methods (e.g. “chip and DIP” and “PTH only”). It is the intent of this revision to correct these problems.

1.2 Assumptions The following is a more detailed description of the assumptions under which we developed the testing matrix.

- **Fluxes/Pastes:** It is assumed that a liquid flux or paste flux has been chosen which has been qualified to J-STD-004. If such a qualification effort has not been made for the flux/paste chosen, then the user must perform the flux characterization tests in those documents.
- **Prior Testing:** It is assumed that the user(s) of this protocol has already performed screening experiments on multiple fluxes and/or solder pastes, yielding information on materials compatibility (e.g., solder masks, temperature maskants, component materials, etc. [sequencing is important too]), expected residue levels, and the impacts of those residues on electrical performance (e.g., SIR data). The idea is that this is not a screening test, you would only do this testing after down-selection, and after you had a reasonable certainty of success.
- **Down-Selection:** Based on the results of the prior testing, a limited number of fluxes or pastes have been chosen for process validation.
- **The Process:** The manufacturing process used in this protocol is assumed to be as close as possible to the process intended for production hardware. Assume that the production process is “good.”

1.3 Other Uses While this Appendix, taken as a whole, is intended for use in validating a manufacturing process, various sections of this Appendix (such as the residue characterization tests, etc.) can be incorporated into a screening experimental matrix, but with smaller sample sizes. Such residue characterization tests can assist the manufacturer in the screening or down-selection process. These test methodologies may also be used to evaluate alternative cleaning methods or flux chemistries.

2 TEST APPROACH

The overall objective for this testing is to demonstrate the compatibility of the “proposed” change with the existing process (e.g., new flux or cleaner, etc.) Testing done to demonstrate this objective consists of two elements, one required and one optional (recommended).

2.1 Element I: Surface Insulation Resistance (SIR)

Testing SIR testing is an evaluation of the effects of the residues (characterized in Element II) on the electrical performance (as measured in SIR degradation) and visual appearance after environmental exposure (e.g., visual corrosion, dendritic formation and mealing of conformal coating [if used]). The rationale is that in principle the old Appendix D (and a number of other, similar industry flux qualification standards) rely on SIR testing as the “acid test” as it is the best way to measure the final effect of the residues on the PWA.

The test approach selected during coordination involves a comparison between the test process and a “minimum acceptable” requirement. The goal of this test is to show with 90% confidence that <10% of the assemblies fabricated using the new process will yield a surface insulation resistance ≥ 100 megohms on the IPC-A-36 interdigitated pad pattern. It is the results of Element I testing that determines the acceptability/compatibility of the proposed change to the manufacturing process.

Allowances are made in Appendix D for the selection of an alternative test vehicle. The requirement in Appendix D is to test a vehicle that is representative of the materials and processes to be used in production. This would include the use of components of the type to be soldered in production representative of the hardest to clean configurations (in terms of “shadowing” of the solder joints by component bodies and component-to-substrate spacings). If an alternative test vehicle is used, the user is responsible for converting the SIR results from the alternative vehicle (using an “ohms per square” approach) to the equivalent of the

response (in terms of components, shadowing, etc.) on the IPC-A-36 assembly (an example of this conversion is given in Section 7.1 of this document).

2.2 Element II: Residue Characterization (Optional)

This consists of a characterization of the species (types) and/or amounts of residues which is accomplished by Resistivity of Solvent Extract (ROSE) testing and Ion Chromatography (IC). Residue characterization data is not used for a “pass/fail” decision, but rather is recommended to provide a baseline for use in process control. Extractive testing by itself is not capable of serving as a pass/fail criteria for a number of reasons:

- Variations from flux chemistry to flux chemistry made generalized conclusions possible but not a firm statement of “less than X will always work.”
- As the flux chemistries of the “control” and “test” processes will probably vary (e.g., RMA vs. Water soluble or no clean), a direct comparison test would not be possible as certain species would only exist in one of the two fluxes being evaluated.

3 SELECTION OF TEST VEHICLE

3.1 General Section 3 covers aspects of the test vehicle used for the process qualification testing. Previous process qualification protocols (e.g. J-STD-001A, Appendix D) made use of a standard test board, the IPC-B-36, which has built a good historical database as a process qualification tool. The pass/fail criteria for this document is referenced back to the B-36 test board.

The user has the option of using the B-36 board, if the user so desires. In many cases, there is a significant difference between the B-36 board (e.g. FR-4) and the production hardware (e.g. polyimide). Many users rightly asked how the test data from the B-36 board translated to their product. In addition, the B-36 board is a mixed-technology, which made it difficult to use in a wave-solder-only or an SMT-only process. So, in the present revision, a section is included to give some guidance to users who wanted to use an alternative test vehicle.

In a review of the available SIR test vehicles, no single vehicle was found which met all the potential criteria for a process evaluation vehicle. Such a “generic” vehicle may be impractical, as it would have to have “a little of everything”; and as such, users would be fabricating many features which they may not use in real life. Thus the decision was reached to leave the existing IPC-B-36 as a “standard,” as it had been used for this purpose for a number of years, while allowing for the development of alternative test vehicles.

If the B-36 board is used as the qualification vehicle, it must be made by one of fabricators used for production bare boards. If you use OSP-coated bare copper, then the

B-36 should have OSP-coated bare copper. It is difficult to get reasonable yields on a B-36 board with a HASL process, due to the fine lines and spaces. Tin-lead reflow is an acceptable alternative to HASL for fabrication of the B-36 test vehicle.”

The B-36 board should also be solder masked with the mask of your choice, but with no solder mask covering the 10 electrical test patterns of the board. It is critical, however, that the solder mask artwork be modified to ensure that the test patterns used for SIR testing are not covered by permanent solder mask.

The basic requirement is that the test vehicle selected, whether the B-36 or an alternate, should represent the substrate materials, assembly materials and fabrication processes used in production. Components of the type to be soldered in production representative of the hardest to clean configurations (in terms of “shadowing” of the solder joints by component bodies and component-to-substrate spacings) shall be included on the PWA.

3.2 Some Guidelines on the Development of SIR Test Vehicle

The following guidelines are offered in the development of alternative test vehicles. A more detailed discussion may be found in IPC-9201, “Surface Insulation Resistance Handbook.”

The spacing of the test pattern and its location shall represent at least one of the following cases (for best results, it is recommended that both types of test pattern be employed).

- An interdigitated pad pattern shall be used to check for “pad-to-pad” contamination which may impact leakage current. This pattern shall represent the closest pad-to-pad spacing to be soldered in production. See the IPC-B-36, test lines M2/E2 (on site D) and M4/E4 (on site C) as examples of this type of test pattern.
- To monitor for contaminants that may “wick under” the device and not be completely removed (due to shadowing by the component), additional test patterns should be located under the component (e.g., two traces parallel to the outline edge of the component). These test patterns should be placed under devices typical of the “worse case” part-to-substrate spacing to be used in production. The patterns shall be placed under the component but near enough to the solder joints to see contamination from this source (typically, the spacing should be 1X-3X the part-to-board spacing). See IPC-B-36, test lines M6/E6 and M9/E9, for examples of this type of test pattern.
- As the test pattern is used to monitor the effect of PWA processing, they must be exposed to PWA processes (i.e., the test pattern must not be covered by permanent solder mask).

Routing of Cathode and Anode: All SIR test patterns consist of a cathode and anode when energized.