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Accelerated Aging for Solderability Evaluations

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A technical report developed by IPC

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Accelerated Aging for Solderability Evaluations

Developed by the Accelerated Aging Task Group of the Assembly and
Joining Techniques Committee of IPC

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Forword

This technical report was developed to meet the growing need for a standard method of evaluating the solderability retention capability of printed circuit parts during inventory storage. Many methods of simulating extended shelf-life were being used in the industry. It was the intent of the IPC Accelerated Aging Task Group to review and evaluate the methods available and recommend a standard procedure to the industry.

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Acknowledgment

Any technical report involving a complex technology draws material from a vast number of sources. While the principal members of the Accelerated Aging Task Group of the Assembly and Joining Techniques Committee are shown below, it is not possible to include all of those who assisted in the evolution of this standard. To each of them, the members of the IPC extend their gratitude.

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Accelerated Aging for Solderability Evaluations

IPC Task Group Report

ABSTRACT

There is a growing need for a method of evaluating the solderability retention capability of printed circuit parts during inventory storage. These circuit parts, including components, connectors, sockets and printed wiring boards are usually joined together by soldering, hence solderability must be preserved during inventory storage. Without accelerated aging prior to solderability testing, i.e. as with the current common practice, little information is gained concerning the future solderability of such parts.

The IPC formed a Task Group to study Accelerated Aging and recommend a method to be used for simulating long term natural storage. This group surveyed circuit manufacturers to determine what was needed, studied the technical literature on accelerated aging and determined that a suitable method is available for tin and tin/lead alloy coatings - the predominant coating materials. In conducting this study, the task group critically assessed the merits of steam, damp, dry, and steam-oxygen heat aging on the basis of published supporting documentation of test results.

The Accelerated Aging Task Group recommends, for tin and tin/lead alloy coatings, a 20 to 24 hours steam aging of specimens above vigorously boiling distilled water to simulate one year natural clean environment inventory storage. This report documents these findings.

INTRODUCTION - TASK GROUP OBJECTIVES

The implementation of solderability testing and enforcement of solderability specifications have become essential requirements for achieving high soldering process yields in the assembly of high technology printed circuits. Solderability tests and specifications have been established by the IPC as well as by other technical societies, the military, corporations and international commissions. It has also become apparent that an additional step must be taken to assure the solderability of components or printed wiring boards prior to assembly. This step is the accelerated aging of such components before solderability testing to make certain that they can be stored as inventory for a reasonable time span without degradation of their solderability. Accelerated aging would be performed on component, socket, connector and printed wiring board surfaces to be soldered subsequent to their individual manufacturing process steps including burn-in or power testing but prior to solderability evaluation. Hence in the sample lot evaluation of parts used in circuit assembly, accelerated aging substitutes for inven-

tory storage and solderability testing is performed last, after all thermal or chemical processing, as a substitute for the soldering process. Solderability testing without accelerated aging provides little information about the future solderability of circuit parts.

An IPC Task Group on Accelerated Aging was formed in 1979 and assumed the tasks of compiling a literature survey, determining from this survey the state of the art of accelerated aging and recommending to the IPC membership an acceptable aging procedure. If necessary, a test program to study aging was to have been initiated. This report documents the findings of the Accelerated Aging Task Group and recommends an aging method for tin and tin-lead alloy coatings on copper base metal. Recommendations are made for other coatings and base metal combinations but only with greater uncertainty in the results to be achieved.

LITERATURE SURVEY

The references cited in the bibliography and the literature overview presented in Tables I(a) through I(d) document the state of the art of accelerated aging.* Since the early 1960's various individuals and working groups have examined accelerated aging methods and made their respective recommendations. With the exception of oxygen enriched steam, as proposed by Wilson⁹ in 1976, dry heat, long term damp heat, and steam aging have been the prevailing methods utilized. While much uncertainty remains as to which method is best, one point is clear: It is highly unlikely that an aging method will be found which will accelerate the aging of all materials at the same rate relative to natural aging. The reason is that solderability degradation usually results from surface deterioration via diffusion, oxidation and corrosion and/or diffusion between coating layers and the substrate such as in the formation and growth of inter-metallic compounds. These chemical and metallurgical reactions occur at different rates for each material combination.

There is reason to expect that an acceptable aging method should be possible for selected groups of materials. First, the elevation of the specimen temperature will increase most reaction rates, particularly diffusion and secondly, Fidos and Piekarski¹¹ have reported a significant increase in the oxidation rate of tin coated wires in the presence of a high humidity (98% RH) compared to the rate in dry air. Finally, Stoneman and Mackay¹⁰, in their study of the degradation of the solderability of tin and tin-lead plated wires

* The information tabulated represents data available at the time of this printing as interpreted by the Task Group.

over a 4-year natural storage period, found the pattern of deterioration similar to that observed for steam acceleration even though an exact “one-to-one” correlation between accelerated and natural aging was not evident. Their study suggests that elevated temperatures of 200°F to 220°F in the presence of water vapor may accelerate the solderability degradation of tin and tin-lead coatings in a manner similar to that of natural aging.

In much of the previous work, emphasis has been placed on the suitability of various solderability test methods or on the shelf life of various solderable coatings rather than on an evaluation of accelerated aging methods. In some instances an author, upon examination of his test results, may have concluded that insufficient justification exists for recommending an aging method; whereas, the combination of several independent research efforts may point to an acceptable aging method. The IPC Task Group has attempted to examine all the independent studies in a collective manner. The Task Group preferred to recommend a method selected by other working groups or associations but usually found insufficient documentation of data supporting their conclusions.

Accelerated aging times cited in the literature range from a short one hour steam treatment to twenty or more days of damp heat. The equipment required varied from inexpensive simple hot air ovens to costly, complex steam and gas mixing chambers. Because of these considerations, the Task Group designed a questionnaire which was circulated to the IPC Assembly Joining Committee membership to determine what was needed by circuit manufacturers in terms of accelerated aging.

NEEDS OF PRINTED CIRCUIT MANUFACTURERS

Most manufacturers responding to the Task Group questionnaire do not use any form of accelerated aging prior to solderability testing, although they agree that a need exists for a standardized aging method. Those that do use accelerated aging use a 1 hour steam treatment and one company indicated that their technical terms of delivery required tin or tin-lead surfaces to be aged 4 hours in 155°C dry heat and other materials in steam for 1 to 4 hours before solderability testing. Qualitative dip testing for solderability takes precedence over newer quantitative methods. The storage capability of components and boards is based on in-house test results rather than external laboratory analysis or international standards, although many responses indicated that attention is paid to technical publications. Once in-house testing is performed, adequate storage life is expected on the assumption that vendors supply parts with coating thicknesses meeting drawing or purchase order specifications.

Questions were asked about component and board coating materials and their thicknesses. The response to the Task Group questionnaire combined with another IPC question-

naire on “Component Lead Materials and Surface Finishes” provides the following information. Data provided by 8 manufacturers which collectively produce over 3,000,000 components per month indicates that nearly 89% of the leads are tin or tin/lead alloy coated, 5% are electroless nickel, 4% electroplated gold and the balance other materials. The tin or tin-lead coatings are typically 300 μinch thick with 100 μinch being the minimum and 2,000 μinch the maximum for hot solder dipped coatings. Gold is typically 50 μinch over 100 to 200 μinch of Ni and nickel is specified at 50 to 150 μinch. The most common component lead base metal is copper with a nickel iron alloy rated second. Tin and tin/lead coatings typically 300 μinch thick are almost exclusively used on printed wiring conductors. The one exception listed was 250 to 400 μinch of nickel. The tin and tin/lead alloys on both components and boards are as plated, fused or hot dipped. A rosin lacquer coating over clean copper is also used on printed wiring boards.

Components and boards are stored in oil free plastic bags often with desiccant packets. Sulfur free packaging materials or boxes are a must. The circuit manufacturers report that little attention is paid to temperature or humidity control. Those that provide control maintain temperature at 66°F to 84°F and the relative humidity between 20 and 65%. Boards and components may be stored for 12 to 24 months with some questionnaire responses indicating that there may be no maximum limit but inventory control is used with a first in-first out policy.

A 24 hour accelerated aging time received the greatest support as a maximum time which would be considered acceptable for routine use. The majority of responses to this question ranged from 4 hours to 5 days. A comment submitted in reply to the question is worth noting: “The highest measure of the usefulness of an accelerated aging test is the degree of accuracy of predicting real performance. The duration (of the test) is less important.” Equipment aging chambers should be large enough to permit aging of large quantities of test specimens in order to meet sample-lot testing requirements. In addition, the facilities should be easy to operate and maintain. In order of preference the following equipment is considered suitable for aging: (1) humidity controlled oven, (2) dry oven, and (3) a steam only facility. The latter facility is much simpler than a gas enriched (oxygen) steam facility, as recommended by Wilson⁹ which was not favored in the Task Group survey. Finally, a pass/fail accelerated aging method is acceptable to those surveyed.

As production volume, circuit complexity, and component density increase, the ability to inspect for and repair solder defects resulting from poor solderability becomes more difficult and costly. The consensus of opinion of the Accelerated Aging Task Group as well as the Assembly Joining Committee in general is that high reliability circuits should not be assembled if components or printed wiring boards