

A Rochester Electronics White Paper



# The Effects of Long-Term Storage on Solderability of Semiconductor Components

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## Introduction

In today's consumer-driven electronic marketplace many products have a limited useful life and component suppliers are moving to shorter product lifecycles. However, there are several industries that require semiconductor components to have a much longer lifecycle. In many cases application lifecycles within the Industrial, Automotive, Medical, Aerospace and Defense sectors may extend up to 30 years or more. As a result, an ongoing component supply becomes critical to sustaining these applications throughout their useful lifecycle. For this reason, it is often a requirement that semiconductor components be stored for extended periods of time after production ends.

When long-term component storage is a requirement, it is important for customers to have confidence that properly stored components are reliable in the field. One key measure of quality and reliability is solderability.

This paper looks at the effect of long-term storage on the solderability of semiconductor components.

## Quality of Stored Semiconductor Components

As with any items that have been in storage for long periods of time, quality and reliability is a key concern. But what is a *safe* Shelf Life for semiconductor components?

While original component manufacturers (OCMs) continue to use date codes as an indicator of when a component may be too old to perform to its original specification, this is no longer accepted as an accurate indicator of quality and reliability. Virtually all components can be used well beyond this manufacturer established date code.

Original Component Manufacturers (OCMs) and *traditional* authorized distributors tend to store components for a few years before turning over the inventory. However, Rochester Electronics has been successfully storing components for extended periods of time to bridge supply chain disruptions for long life applications since 1981. They have become known as the premier leader in providing a continuous *Authorized and Guaranteed* source of supply for end-of-life (EOL), also referred to as obsolete, semiconductors for decades without degradation to the product.

One concern for component end-users is Tin Whiskers. Tin Whiskers are electrically conductive, "whisker-like" structures that grow off the surface of component leads where Tin (or Tin alloys) is used as a final finish. These whiskers have been observed to grow from lengths of several millimeters (mm) to up to 10mm, potentially causing electrical shorts and damaging the equipment that incorporates the semiconductor components. In fact, tin is not the only metal that may form whiskers. A number of other metals have also been known to be capable of growing these structures.

According to NASA (National Aeronautics and Space Administration), "a single accepted explanation of the mechanisms of Tin Whiskers has not been established" [1], and whisker growth has been reported after an incubation period that varies from seconds to years. Hence, there is no direct link between whisker growth and component age.

One accepted measure of the quality and reliability of components in the field is Solderability after long-term storage. One OCM, Allegro Microsystems, who is one of over 70 *Authorized Rochester Supplier* partners, has performed solderability studies based on the “Wetting Balance” methods on components stored at ambient conditions for up to 10 years. They concluded that long-term storage does not affect solderability and that “storage in a sealed bag is more than adequate”. Furthermore, Allegro Systems indicated that levels of oxidation accumulated from exposure due to long-term storage did not affect the solderability of the components [2].

Another of Rochester’s Supplier partners, Texas Instruments, published a detailed study on Component Reliability after Long Term Storage [3]. They concluded that the Shelf Life of semiconductor components that had been stored in a warehouse environment, with and subjected to several tests including solderability, Scanning Electron Microscope (SEM) visual, SEM spectral analysis, optical microscopy, Moisture Sensitivity Level (MSL) performance and decapsulation/visual, is >15 years.

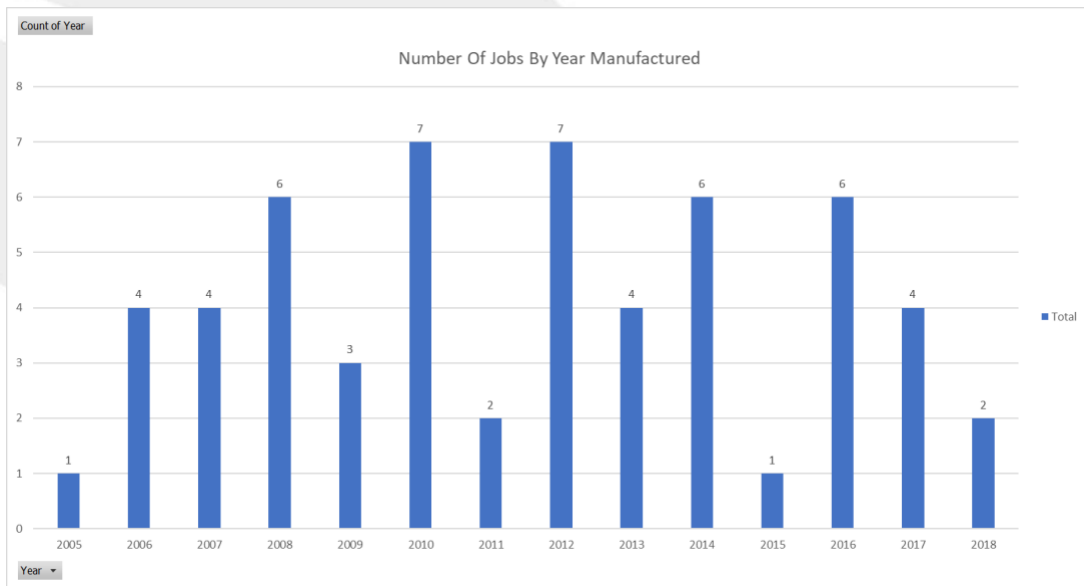
Given Rochester Electronics’ extensive inventory of components that extend to over 35 years, the company is uniquely positioned to understand the key issues that can affect the quality of aged components.

## **Investigation on Solderability on Aged Components**

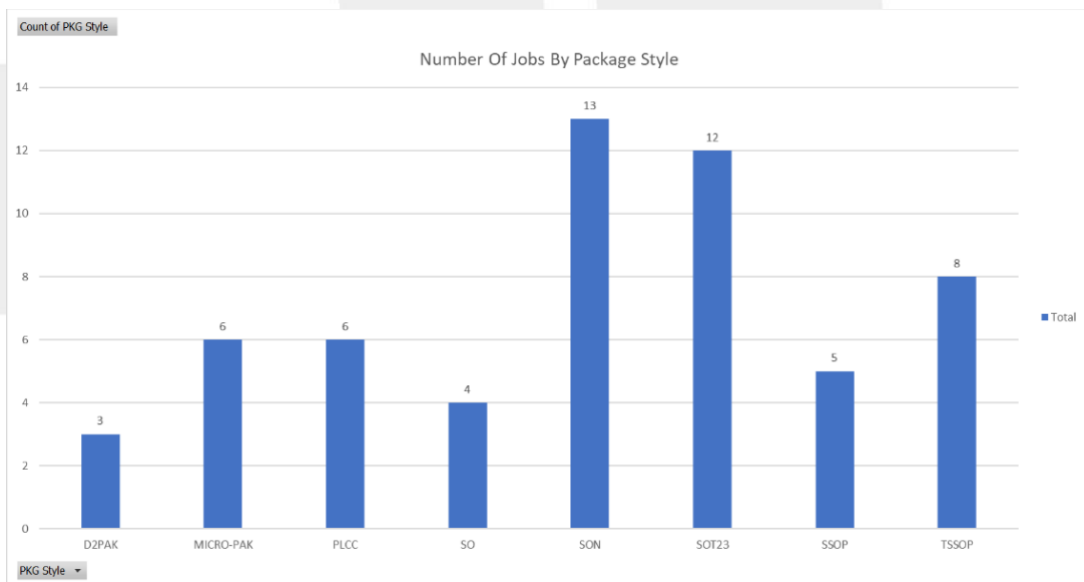
To determine the quality of aged semiconductor components in real-world applications, Rochester Electronics has performed an analysis on solderability by using an industry-standard board mount with solder paste and reflow manufacturing process.

Rochester used the services of an independent 3<sup>rd</sup> party electronic manufacturing company, experienced in PCB assembly, to undertake the assembly and testing process. The contract assembly house is fully ISO9001 certified and has over 17 years of experience.

A random selection of lead-free surface mount components from Rochester’s inventory was used in the experiment with ages ranging from 3 to 16 years, and an assortment of package styles, per **Figures 1 and 2**.



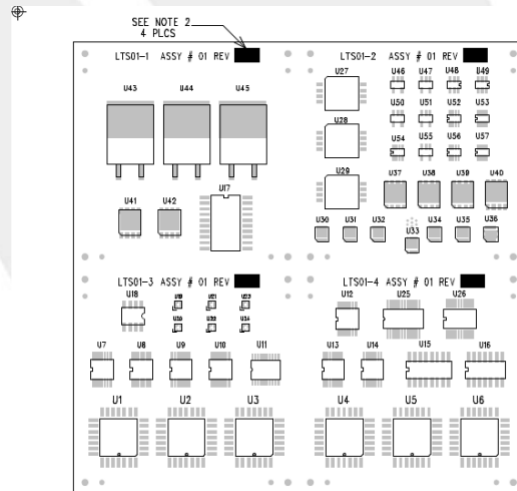
**Figure 1:** Age of semiconductor components used in the solderability test



**Figure 2:** Number of semiconductor components used by package style

### Details of the Production Assembly process:

Rochester randomly selected 57 different tape and reel date codes of lead-free surface-mount packages from inventory. For each date code, pad layouts were designed for inclusion on copper-based PC boards. Each board contained 57 positions (one for each date code).

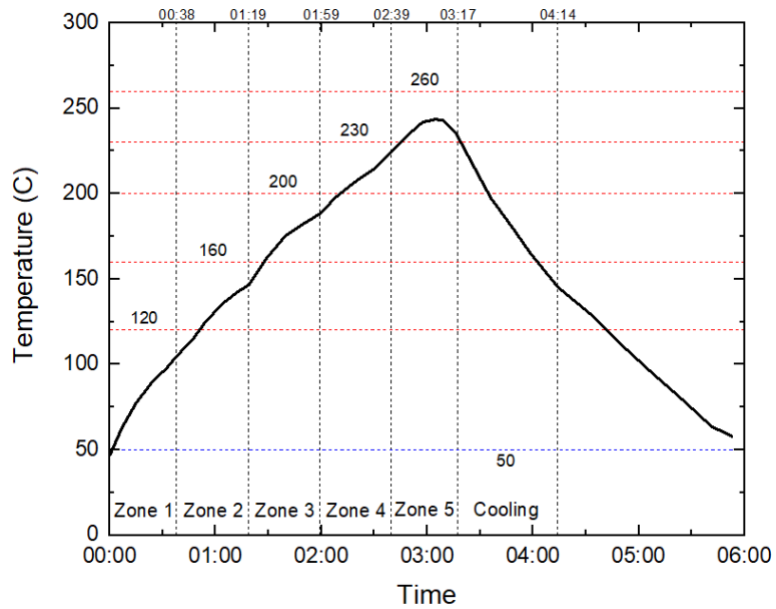


**Figure 3:** Layout of PCB board used for assembly process

The manufacturing contractor assembled 10 single-sided boards and 10 double-sided boards through its' standard production assembly process.

### **Assembly Process outline was as follows:**

- a. Components loaded automatically from tape and reel
- b. The solder used was Lead-Free OA Alpha 152996-1998
- c. Position each of the 57 date codes on the board
- d. Once all components were positioned on the board, process the board through the reflow oven
- e. The nominal time through oven was 4 minutes 30 seconds
- f. Reflow temperature profile per figure 4.
- g. Boards were cleaned after reflow prior to inspection.



**Figure 4:** Temperature profile of solder reflow cycle

**Results:**

Once the manufacturing process was completed, all the boards were Inspected to industry standards by the manufacturing contractor.

**The extract from the final report was as follows:**

- X-Ray at each component location
  - **No defects were found**
- SMT Inspection to IPC (Institute for Printed Circuits) CLASS II
  - **No defects were detected**
- Automatic Optical Inspection (AOI) was 3D Programmed Final Board Inspection
  - **No defect concerns detected**

## Conclusions

The usability of semiconductor components having been properly stored for periods of up to 16 years has been examined based on component solderability.

An analysis was performed using the services of an independent contract manufacturer utilizing an industry PCB manufacturing process and state-of-the-art inspection techniques.

In this analysis a broad range of samples were used from multiple OCM finished goods stock. The samples represented a variety of package styles, lead counts, various based metal and final lead finishes (including NiPdAu and pure tin) with date codes ranging from 2005 to 2018.

**These independent tests confirmed that no negative effects due to component aging were found to impact the solderability of components which have been properly stored for extended periods of time.**

## References

[1] <https://nepp.nasa.gov/whisker/background/index.htm>

[2] Allegro Microsystems, Application Information – “Handling, Storage, and Shelf Life of Semiconductor Devices”, Sep 2019. See: <https://www.allegromicro.com/en/insights-and-innovations/technical-documents/general-semiconductor-information/semiconductor-handling-storage-shelf-life>

[3] Texas Instruments, Application Report – “Component Reliability After Long Term Storage”, May 2008