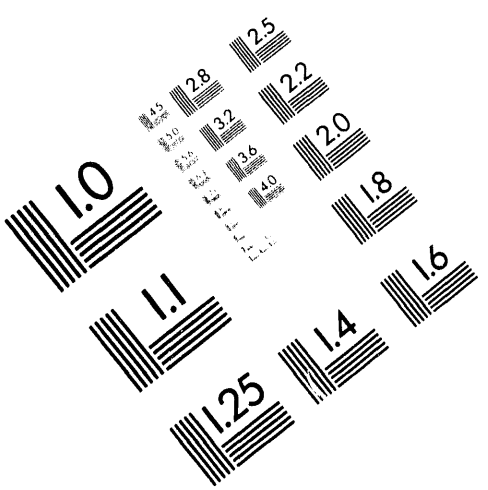

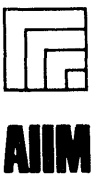

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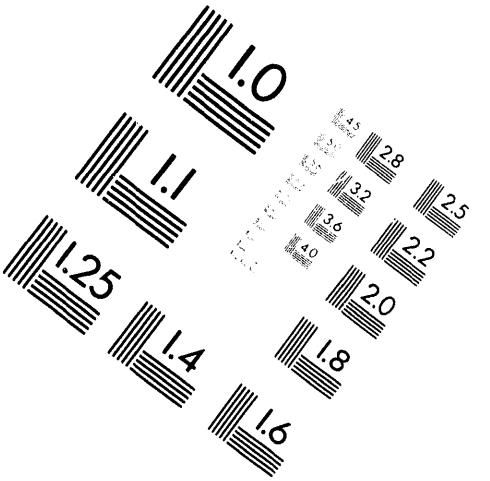

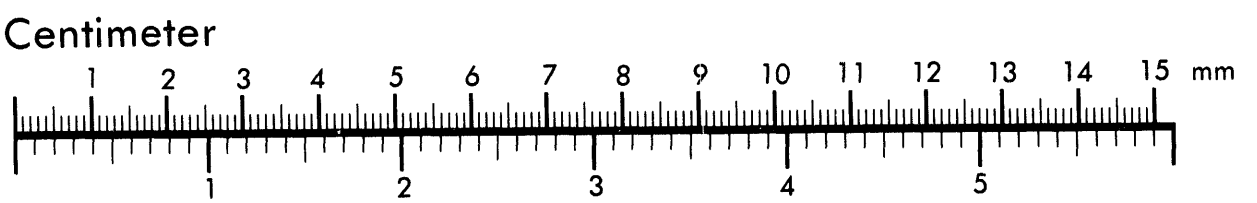

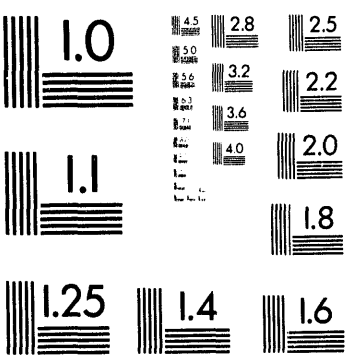

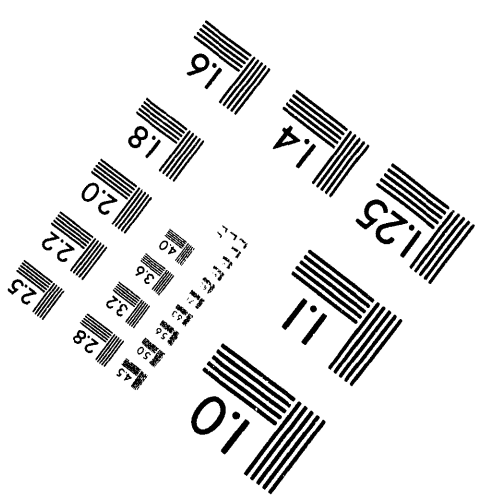

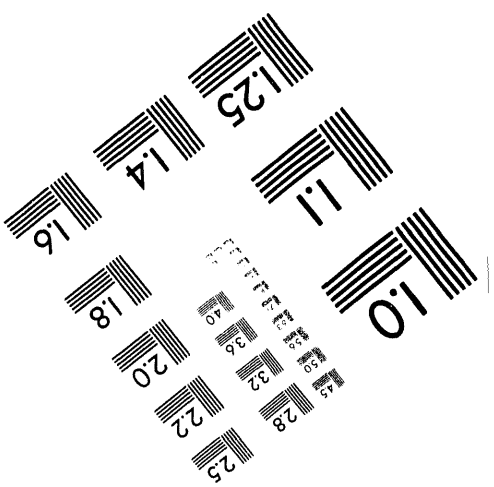

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Aging of D-limonene-Cleaned Assemblies

Kansas City Division

T. A. Somer

KCP-613-5273

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Topical Report

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Topical Report
T. A. Somer, Project Leader

Technical Communications
Kansas City Division

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Abstract

The performance of 2000 electronic circuit variables was monitored throughout a 5000-hour exposure to +160°F. The 2000 variables involve 36 electronic assemblies, cleaned with various solvents, including d-limonene, as a replacement for TCE. The assemblies were divided into four groups, including a TCE-cleaned control group at room temperature. Of the three groups exposed at +160°F, one was cleaned in TCE, one was cleaned in d-limonene, and one was kept in a saturated d-limonene atmosphere. No performance degradation was observed with any of the groups, including the worst case exposure in a saturated d-limonene atmosphere.

Summary

This part of the project studied the aging of selected electronic assemblies and cables cleaned with various solvents, some with d-limonene and others with trichloroethylene (TCE) and isopropyl alcohol (IPA). The total study will track the electrical performance of 36 assemblies for 9000 hours. To date, 5000 hours have been accumulated and data has been collected from samples divided into four groups:

- Control group at +75°F
- TCE/IPA cleaned at +160°F
- D-limonene/IPA cleaned at +160°F
- Saturated d-limonene atmosphere at +160°F

The study includes twelve 28-channel high voltage transient suppressor assemblies, ten 20-position rotary switch assemblies, and fourteen cables, with over 2000 measured electrical parameters. These measurements have been repeated ten times during the initial 5000-hour period.

The most important observation is that the exposure to a saturated d-limonene atmosphere at +160°F for 5000 hours has not produced any detectable changes in the electrical performance of the measured parameters. Furthermore, there are no performance differences among the four groups and no time/age correlated performance degradation.

Discussion

Scope and Purpose

Some minute quantity of d-limonene can and will remain in an assembly or can get into components during the d-limonene cleaning process; therefore, there is a concern about d-limonene's long-term effects on electrical parameters and/or reliability. This study focuses on the aging characteristics of circuits cleaned with d-limonene and also on assemblies where established cleaning methods were used.

Prior Work

This work was started over two years ago to supplement the massive efforts in evaluating d-limonene as a replacement solvent for TCE. One important consideration for a replacement solvent is cleaning efficiency, which was amply demonstrated for d-limonene in an earlier study.[1] Investigation of the long-term aging effects of d-limonene on electronic assemblies and associated components and materials was imperative to ensure systems compatibility.

Activity

Sample Groups

Test samples were selected and prepared. All samples are aged without the application of power. The units are powered up only during periodic electrical testing.

Control Group at +75°F

Units in this group are characterized by collecting 137 high-impedance measurements ($R > 10^9$ ohms), 91 low-impedance measurements ($R < 0.06$ ohms), and 68 mid-impedance measurements.

TCE/IPA Cleaned Group at +160°F

This group is characterized by collecting 208 high-impedance measurements, 138 low-impedance measurements, and 102 mid-impedance measurements.

D-limonene/IPA Cleaned Group at +160°F

This group is characterized by 162 high-impedance measurements, 114 low-impedance measurements, and 68 mid-impedance measurements.

D-limonene-Saturated Atmosphere at +160°F

This group was in a saturated d-limonene atmosphere at +160°F, which is considered a worst-case situation. This group is characterized by 255 high-impedance measurements, 151 low-impedance measurements, and 170 mid-impedance measurements.

Each group of samples is stored in a separate desiccator and the only time the samples are removed from desiccators is for electrical testing. The saturated d-limonene atmosphere is maintained by keeping a small open container of d-limonene solvent inside the desiccator with the samples. D-limonene solvent is

added periodically to compensate for losses caused by evaporation.

Test Plan

At the beginning of the study, before the temperature exposure, all units were tested several times to establish a room temperature baseline. At the time the study was started, there was no information on aging characteristics of electrical parameters in the presence of d-limonene. To avoid the risk of damaging all of the samples early in the study, the evaluation was started with frequent testing and short temperature exposures at +160°F.

Initially, the units in the saturated d-limonene atmosphere were tested every 24 hours; the other groups were tested every 150 hours. After no performance degradation was observed, the time between electrical testings was gradually increased to the present 700 hours. For testing, the samples are removed from the elevated temperature and then allowed to stabilize at room temperature. All DC testing is being performed on the PT3300 multipurpose tester. The PT3300 is part of a network data acquisition system (DAS), which facilitates data collection.

Observations

More than 20,000 data points from 22 assemblies and 14 high voltage cables have been collected and stored in the DAS system during the past year. Because the DAS system is limited in time-related statistical data manipulation and data consolidation, the data was transferred into the mainframe CMS system. In the CMS system, like variables for each serial number were combined and the mean and ±3 standard deviation were calculated at each test date.

No time-related performance degradation has been detected in any of the samples including the worst-case samples in saturated d-limonene atmosphere at +160°F for 5000 hours. Sample data is shown in Figures 1 through 4.

Figure 1 shows data for two low-resistance circuits in an assembly (part of the control group) at 75°F. Figure 2 shows the data for the identical two circuits but in a different assembly in the saturated d-limonene atmosphere at +160°F for 5000 hours. For both units, the readings over the 11-month period have remained within ±335 micro ohms or within ±1% of the nominal 35 milliohms. It is important to note that the 5000-hour exposure to +160°F in the saturated d-limonene atmosphere has not caused a drift in the measurements.

Figure 3 shows leakage current data for an assembly in the control group. The mean and ±3 sigma leakage current readings are determined for 14 identical filtered circuits. As expected for a control group unit, the leakage current readings have remained constant over the 11-month test period.

Figure 4 shows leakage current data for identical circuits, but from a different assembly, in saturated d-limonene atmosphere at +160°F, remaining constant throughout the 5000-hour test. Again, there were no detectable aging effects.

Accomplishments

After a 5000-hour aging study at +160°F, there was no observable performance degradation in any of the four groups. D-limonene was shown to be an effective cleaner of the primary intentional contaminants (Kester 197 solder flux and RAM 225 mold release) and, therefore, a good replacement for TCE.[1] The results of this study further support the use of d-limonene as a replacement solvent for

TCE by showing that 5000 hours at 160°F has not produced any performance degradation, even in the saturated d-limonene atmosphere.

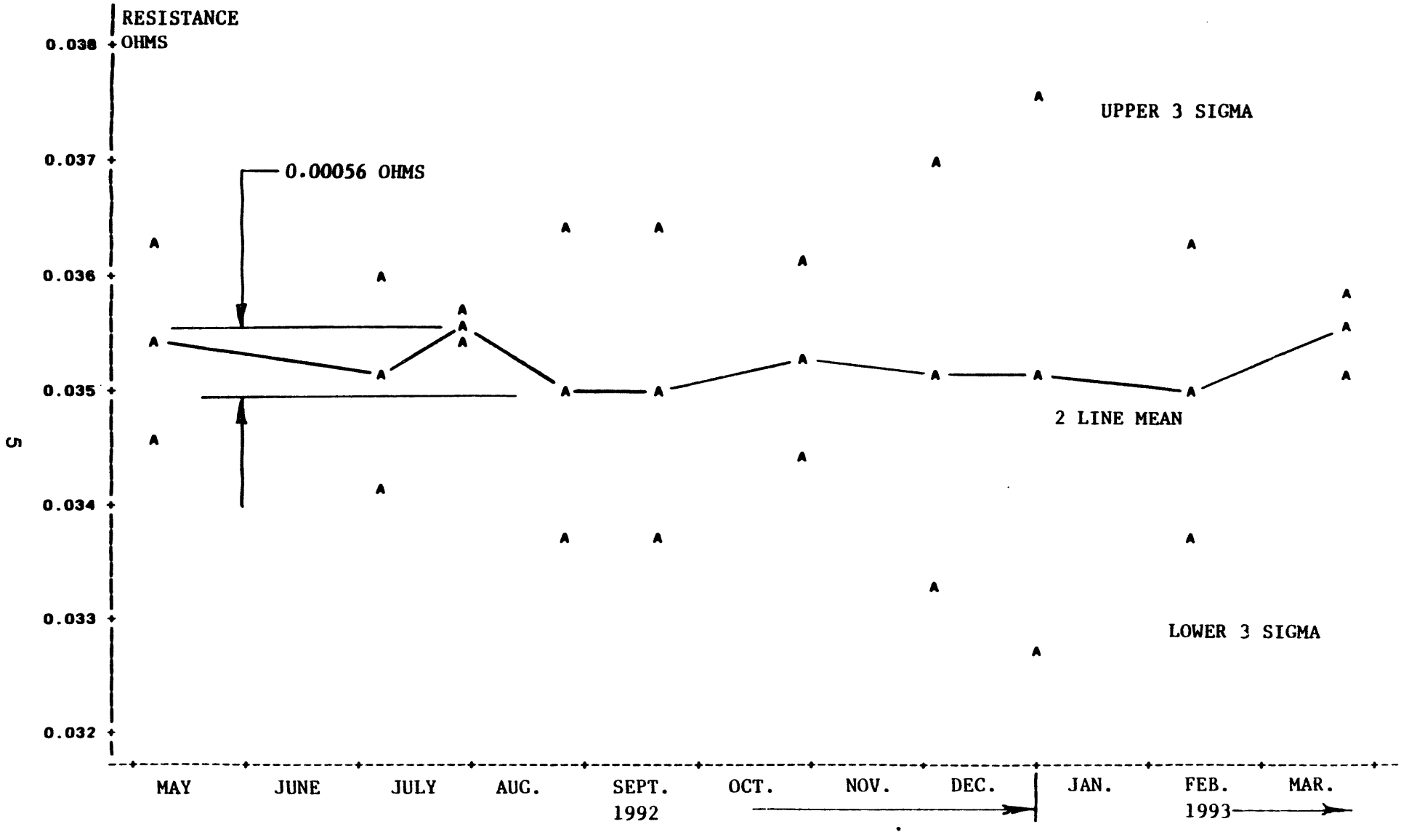

Figure 1. Control Group Sample at Room Temperature—Circuit Path Resistance of Two Connectors, Circuit Board, and Wire

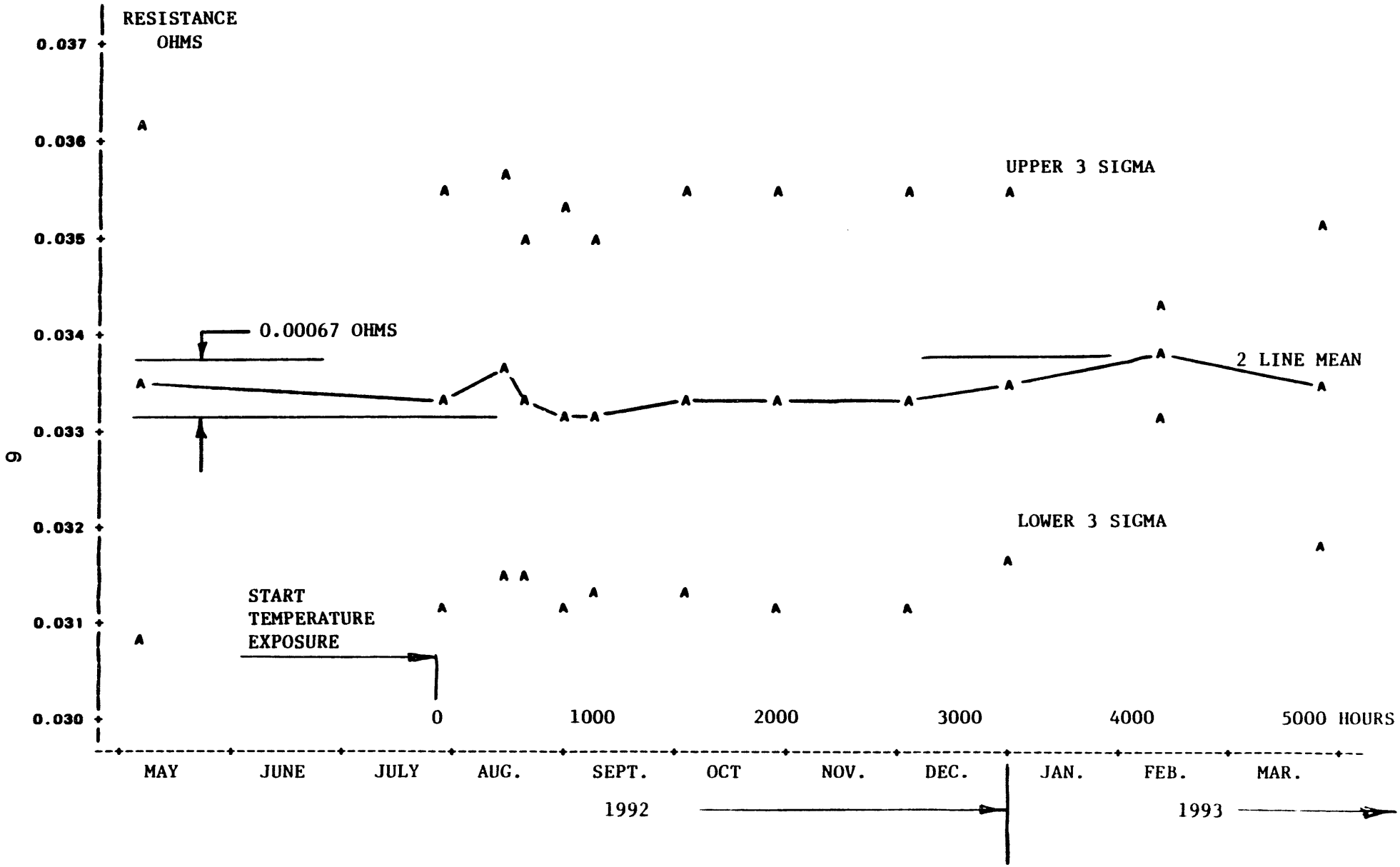

Figure 2. Circuit Path Resistance of Two Connectors, Circuit Board, and Wire—5000 Hours at + 160°F, Saturated D-limonene Atmosphere

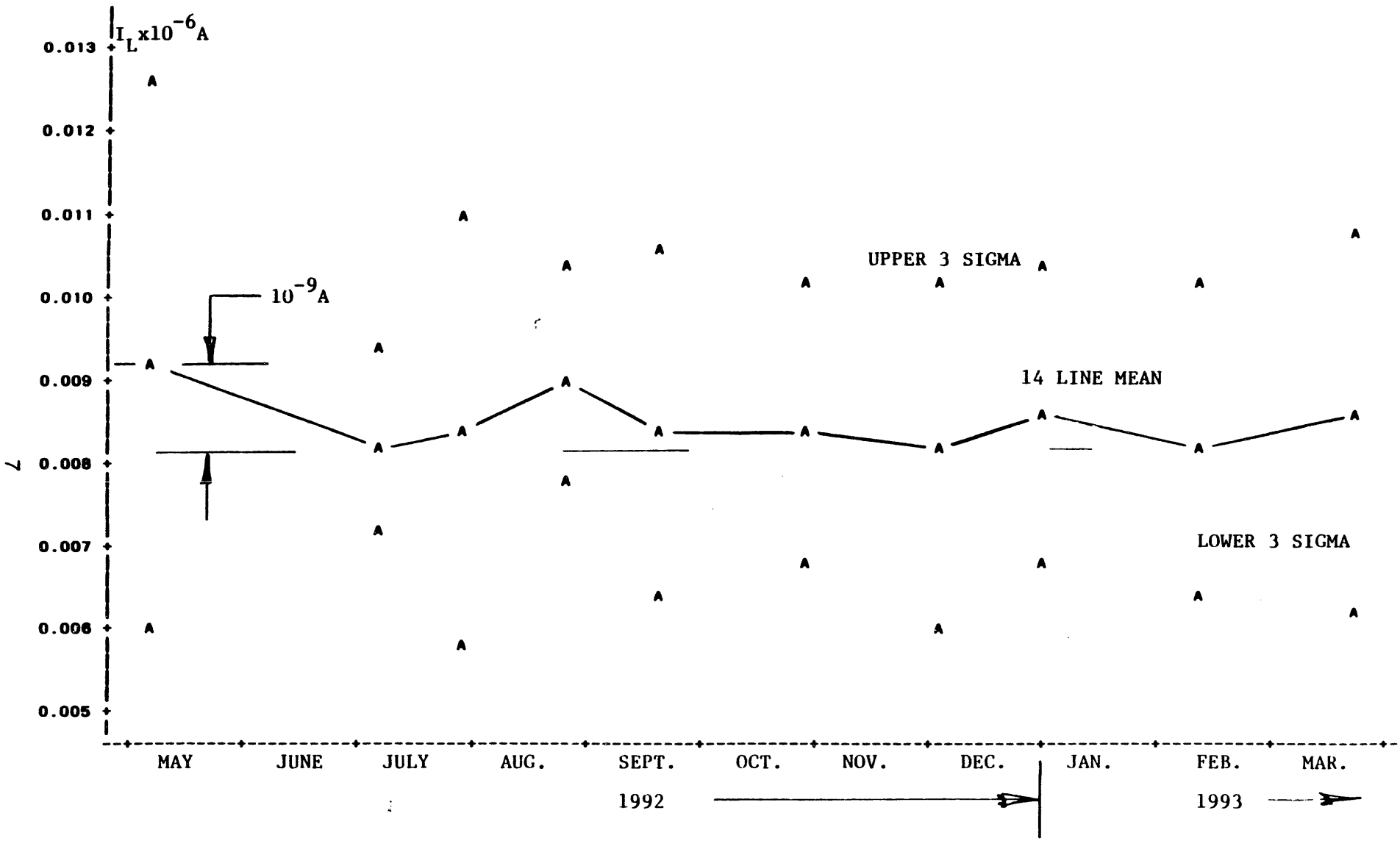

Figure 3. Control Group Sample at Room Temperature—Leakage Current at 40 Volts, 14 Filtered Lines

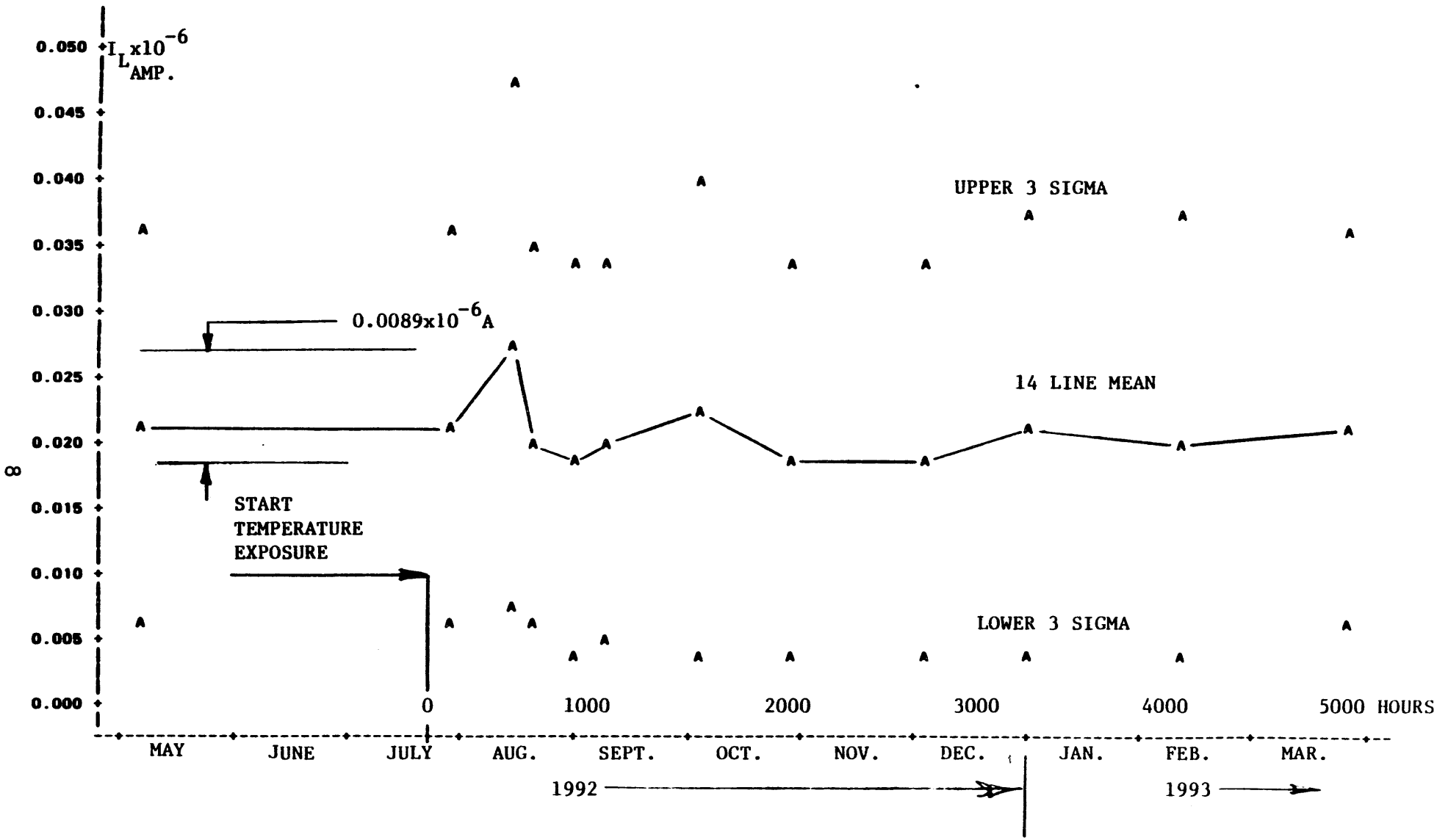

Figure 4. Leakage Current of Circuits at 40 Volts, 14 Filtered Lines—5000 Hours at + 160°F, Saturated D-limonene Atmosphere

Reference

[1]M. G. Benkovich, "Solvent Substation for Electronic Products." *International Journal of Environmentally Conscious Manufacturing*, Vol. 1, No. 1, 1992.

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