BY RICHARD RICE • INDEPENDENT CONTRACTOR

A lesson in humidity? No sweat

DANIEL VASCONCELLOS

Years ago, I started a new job as a senior engineer for a medical-device company that designed and manufactured products for use in cardiology to diagnose heart arrhythmias and other types of patient monitoring. My first assignment was to explain and fix the outrageously high failure rate of a Holter recorder. In 1961, American biophysicist Norman Holter, MD, invented the device, which uses electrodes connected to the patient's chest to record the ECG (electrocardiogram) waveform over a 24- or 48-hour period. The long recording period allows cardiologists to capture any ECG events that may occur only during certain times of the day or during certain activities, such as while a patient is sleeping or at work.

As I began to investigate, I found out that this situation had been going on for some time and customers were now demanding new units. Our repair department generally could not find anything wrong with the recorders, even though customers would send along recordings showing ECG waveforms that would "go nuts" with huge amounts of noise, swinging from rail to rail for varying periods—sometime for hours. I estimated that the company had scrapped $800,000 worth of parts.

After spending a week or two looking over schematics and talking to everyone I could find who might have a clue, I decided to do some environmental testing. Bingo. I was able to re-create the failure mechanism by raising the humidity level. As I thought about it, it all started to make sense. Patients wore the recorders to bed at night under the covers; they showered with them on. Patients entered warm rooms from the cold outdoors, causing condensation to form on the PCBs (printed-circuit boards). About two in five would fail at high humidity, and all would fail with condensation. Most would recover and work fine after they dried out, but some sustained permanent damage.

A little more investigation and a long talk with a chemist from our hybrid lab led to a conclusion: Humidity, along with hydroscopic surface contamination, absorbs moisture from the air, resulting in conductivity along the surface between traces. The leakage causes metal-migration electroplating. Branchlike structures, or dendrites, form between the traces, causing microscopic short circuits that are so small they blow open like a fuse as the current rises. The abruptly changing leakage currents were causing the noisy ECG signals. Keeping the surface clean is important but does not prevent condensation problems because the water can absorb carbon dioxide from the air, forming carbonic acid, which is conductive.

The solution was to clean, dry, and then coat the entire PCB with a conformal material to keep moisture out. It took a lot of effort to get someone to make the tough decision to go ahead with the process change. Once they got the OK, some of the engineers went to work on the weekend, and, by Monday morning, they had hooked up a dishwasher to a deionized-water source. Using that machine along with an electric oven, both from Sears, they had the conformal-coating process up and running a few days later.

So, the Holter-recorder problem had disappeared, and I was a hero for about 15 minutes. We could do nothing about the boxes of scrapped recorders or those still out in the field. EDN

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