We're All Fed Up

Recreating failure mechanism in ovens

Foresite Inc.

Every once in a while, when doing failure analysis, it becomes necessary to try to recreate a failure mechanism in order to determine the base problem. In many cases, this is a mundane process, but is occasionally fun, such as when you get to pour diet soda on energized circuitry. In this month's case study, we present an approach we used that was decidedly different, and probably hazardous to our health.

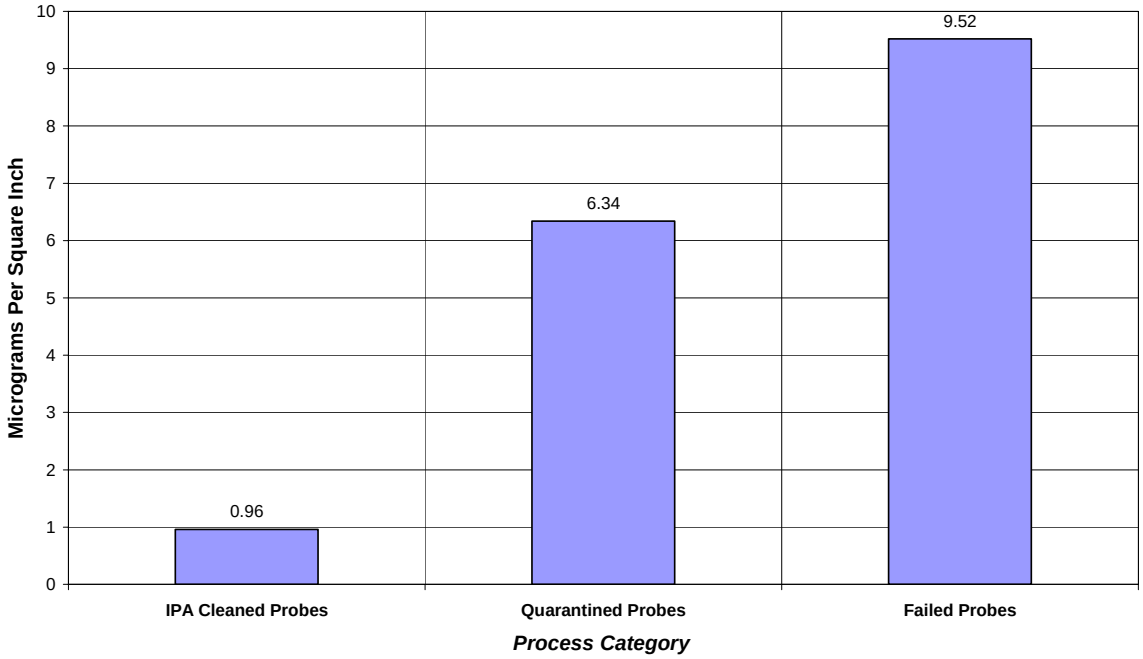
The customers were a manufacturer of thermocouple probes that were used to control household oven / range units, and the manufacturer of the ovens themselves. Over the Christmas season, a high incidence of failure was noted on the newest oven units, usually with very little service time. The failures seemed to occur more when turkeys and hams were baked, or when the ovens were subjected to the high temperature self-cleaning process. Figure 1 shows the oven diagram.

The temperature probes themselves were an alumina base, with an epoxy beaded thermocouple on the end. Two wires were attached to the opposite end of the probe using a hot-bar reflow (700^{o}F) soldering process and a flux believed to be halide activated. The probe assembly was contained inside of a stainless steel tube that passed through the oven wall. During the information gathering portion of the project, we found out the following:

- The qualified process had transitioned recently from California to Mexico
- There were no similar problems before the transition
- Cleaning the suspect probes in TCE or isopropanol seemed to solve the problem
- About 14,000 units were in a quarantined condition pending resolution of the problem
- Replacing the field probes with new probes also resulted in quick failures

Chart 1 shows the analysis of the probe assemblies and materials by ion chromatography.

Chart 1
Chloride Levels on Oven Probes



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The manufacturer of the ovens shipped us a new unit for our experiments. Over the course of two weeks, we baked hams, turkeys, cakes, brownies, etc. in an effort to duplicate the failure mechanism (which we did). After a number of different analyses, we came to the following conclusions:

- The failure mode was electrochemical migration between the two wires used to attach to the probes.
- There was no single problem to correct, but a series of problems
- There were high levels of chloride in the wire attach areas. The current production probes, which were cleaned, had little to no chloride and no failures could be forced. The failed units had high levels of chloride as did the units in quarantine
- The stainless steel enclosures for the tubes were thought to be fully crimped, isolating the two ends of the probe. This was not the case and moisture laden air could escape through the probe opening, especially when the (primary) oven vent through the range top was blocked by other kettles
- There were a number of odd manufacturing practices in use at the Mexico facility including improper use of a wave solder de-drossing agent

The customer implemented a number of process reforms in the new facility, including a cleaning process for the probes after wire attach. The quarantined probes were cleaned to adequate halide levels. Efforts are under way to improve the crimp seal in the stainless steel housing to prevent oven air from escaping through the probe unit. The manufacturer is also planning on getting away from the use of halide-bearing fluxes in order to eliminate the cleaning process.

While it was gratifying to solve the customers' problems, it was also a great pleasure to have Christmas dinner every day for two weeks. However, it was probably not the most healthful approach. The cholesterol spike alone should have killed us. We all gained about 10-15 pounds each. Now we are hoping that NordicTrak has a problem that we can tackle.

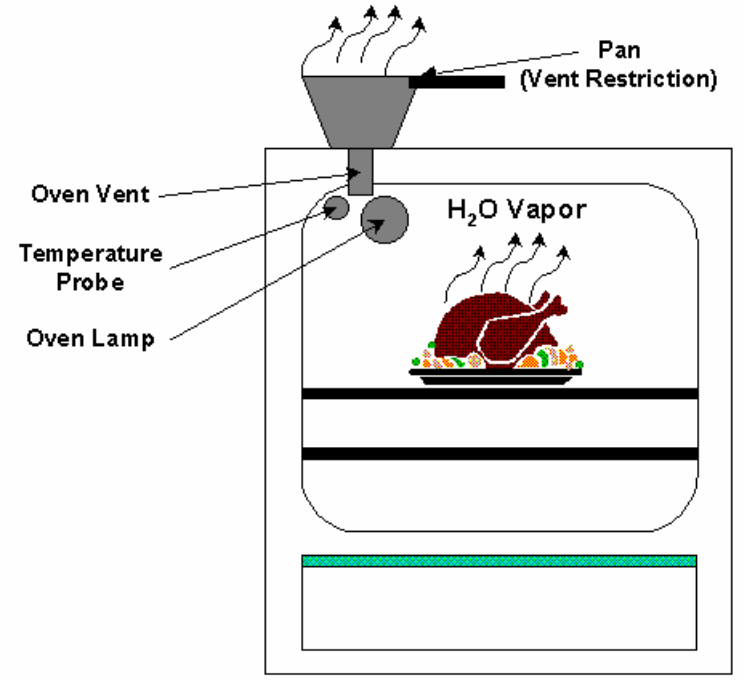

Figure 1.