That Darn Casting

Beware of Contaminants from Casting

Foresite Inc.

In this study, we examined outside factors that were causing circuit failures during the burn-in acceptance test (power temperature cycling). The assembler in this case made electronic assemblies for automotive applications. The assembly was manufactured from standard FR-4 laminate, solder masked with an LPI, processed with water-soluble fluxes and pastes and aqueous (tap water) cleaning, and conformally coated. After processing, the assemblies were placed into aluminum castings, which formed a shell around the assembly, but the unit was not hermetically sealed. After the units were assembled, they were placed into a large temperature-humidity chamber (room sized) for burn-in testing. This was a high volume assembler, and so thousands of units were power tested simultaneously. Following this testing, a number of unit failures were noted and separated out for analysis. Each of these units appeared to have a residue pattern that suggested that a fluid had dripped onto the failure site and eaten through the conformal coating, causing corrosion and electrical failure.

The assembly process was examined from start (bare boards) to finish (prior to conformal coating), along with the failed assemblies, to determine the source of the detrimental residue. The bare boards were fairly clean and determined as a non-factor. The processed assemblies had chloride levels slightly higher than we recommended. Some improvements were made to the cleaning process, but the residues were uniform across the assembly and did not match the contamination patterns of the failed assemblies. The failed assemblies had high levels of chloride, sulfate, and nitrate in the failure areas. In the non-failure areas, the assemblies had chloride residues consistent with the manufacturing process, and no sulfate or nitrate. An analysis of the inside surfaces of the aluminum castings, which no one had thought to check, showed high levels of chloride, sulfate, nitrate, and a conductive organic material. Somehow, these residues were transferred to the assembly during burn-in testing.

After much analysis, we determined the failure mechanism. The burn-in ramp-up method went from ambient or sub-zero temperatures to over 70°C in a very short time span. The heavy thermal mass of the castings kept the castings several degrees colder than the surrounding air. Moisture would condense on the inner (and outer) surfaces of the castings, dissolving the residues from casting and transferring them to the circuit assemblies. The combination of an ionically charged solution and the electricity available (a powered test), served to eat through the coating and start a corrosion cell.

Most metal casting operations are “dirty” by electronics standards. Most cleaning operations involve a simple rinsing with a detergent solution. We found that the casting cleaning was done with an ionic detergent and rinsed with tap water. The conductive organic residue we found to be the residual detergent. Once the residue levels on the castings were identified as a contamination source, a designed experiment was used to improve the casting cleaning process, drastically reducing the residue levels. In addition to the casting cleaning changes, the assembler slightly modified the burn-in ramp-up steps, allowing for a slower change between temperature extremes. This allowed the aluminum castings to change temperature at a rate much closer to the surrounding air, lessening the chance for condensation to form on the casting walls. These two changes have solved the problem.

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