Risk Scenario: Breakdown of Production-Critical Infrastructure

When RoHS strikes back

In today's technically advanced countries, supply of water and electricity is considered so very secure that most infrastructure-based risk scenarios focus mainly on computer networks. We can just barely imagine living on without that continuous flow of data. If, as in this case, a customer experiences an increase of electricity blackouts in production, risk indicators for Probability go deeply red. Indicators for Impact aren't very different when manufacturing, the company's "money press", looms to stop.

Temporary incidents less severe than the consequences

The customer operates a small and neat while very energy-intensive production. Just some years ago they have completely renewed their facility, including the entire electrical system. A maintenance-friendly, modern power bus system was chosen for the in-house distribution. Surprisingly spontaneous electrical breakdowns already occurred several times. And strangely, none of the experts could find the clear cause. After the precautionarily evacuated crew returns to the premises, the stopped machines have to be brought back into operation. Parts have to be sorted-out, and machined from scratch. Quickly all that has grown an enormous amount of cost.

The usual suspects were not to be found

For short cuts in bus bar systems, the electrical engineer usually expects to find visible causes. A dead mouse as a victim of their own curiosity, for example, or wire debris with open conductor ends, sometimes even a forgotten screwdriver. Nothing like that could be found; even the connected machines provided no indication. Based on the detailed risk assessment the management started evaluating specific countermeasures: such as a redundant, second distribution network, and UPS systems, to allow at least a secure shutdown to the most delicate machinery. That cost would be considerable as well.

A barely known phenomenon

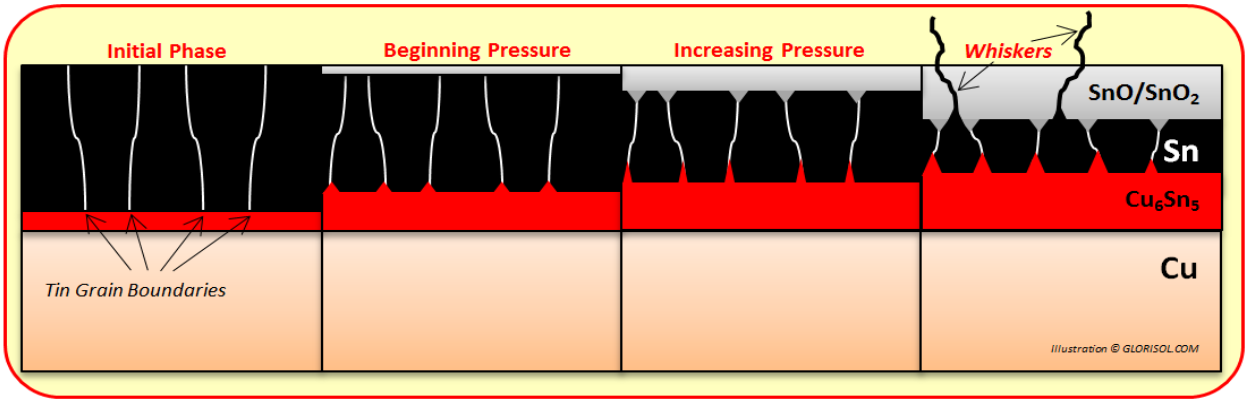
Only few experts are familiar with it, but likely it will occur more frequent now: Some years ago, politics set the goal of better protecting the environment from avoidable impurities, especially that no more lead gets into the water cycle. The European Union started the RoHS program and lead has to be renounced in the vast majority of electronic products. This increasingly leads to strange effects that apparently nobody had on their screens.

What are these Whiskers and where they're from?

Don't worry: Even if you have a cat allergy, you can carry on reading. Metals can produce thin hair-like fibers, too. And apparently this happens more and more frequently in bus bar systems. Usually these "hairs" are only a few microns thin and not very long, but that may be enough to shorten safety distances in electrical installations. If an electric arc is then set off between two current potentials, usually the entire system switches off in consequence. What's left of these thin metal hairs afterwards still looks like dust particles at best.

However, the topic isn't that new. In the 50s, tin whiskers had appeared on printed circuit boards. At that time, just a little more lead was put into the solder alloys and the issue was solved. Today, after the lead ban, this simple solution is no longer a viable way out.

Unfortunately, the formation of Whiskers is still not entirely understood. Still, the following explanation sounds enlightening: Electric bus bars are mainly made of copper with a tin surface protection layer. When copper and tin get into contact, an electrochemical process slowly starts to form an intermetallic separation layer of Cu_6Sn_5 between them - this occurs even at average room temperature. The Cu_6Sn_5 is growing in volume over time underneath and between the tin grain structures, putting pressure on the tin crystal grains. Even more pressure to the tin grains comes from the other side: Simple surface oxidation produces another layer of SnO and SnO_2, which also grows around the tin crystal grains and into their interstices. And it's still not exactly clear when a tin grain can no longer withstand the increasing pressure and Whiskers of mono-crystalline tin will spread out of the surface.



Influence factors and possible counter measures

Whitish points occasionally arise on tinned surfaces, from which whiskers grow later. Tin whiskers are only about one tenth of a human hair in diameter. Still, they can be life threatening, when an electrician opens a switchboard and a whisker moved by the air leads to an electric arc.

A basic remedy would be to convert to uncoated copper and conventional cladding of the bus bars. Also whiskers are more likely to occur on glossy tin topcoats than on dull finish surfaces. So the chosen electroplating process seems to play a role. Heat treatment of the tinned power rails appears to reduce the tendency for whisker growth because the tin coating afterwards becomes more resistant to the pressure due to larger grain diameters. Also, separating layers of nickel or silver in-between tin and copper appear to slow down the growth of the separation layer of Cu_6Sn_5.

Basically, a more frequent and meticulous cleaning must be part of the maintenance plans. Of course, open and clean switchboards only when they're switched off (for the reason above). Especially important are intact dust seals inside the electrical installation. Because not only Whiskers, but also other particles can be sucked with the air from the furthest corners of the installation to that places where they become as a risk for maximum damage.

Did you find this helpful or inspiring? Are you aware of in-depth root cause analysis on crystallographic influences on whiskers formation? Please feel free to provide feedback under subject "Whiskers - Risk". GLORISOL® supports you in risk analysis, strategic risk management, supply chain organization, supplier management and global sourcing.