

'Tin whiskers' imperil electronics

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They've ruined missiles, silenced communications satellites and forced nuclear power plants to shut down. Pacemakers, consumer gadgets and even a critical part of a space shuttle have fallen victim.

The culprits? Tiny splinters — whiskers, they're called — that sprout without warning from tin solder and finishes deep inside electronics. By some estimates, the resulting short-circuits have leveled as much as \$10 billion in damage since they were first noticed in the 1940s.

Now some electronics makers worry the destruction will be more widespread, and the dollar amounts more draining, as the European Union and governments around the world enact laws to eliminate the best-known defense — lead — from electronic devices.

"The EU's decision was irresponsible and not based on sound science," said Joe Smetana, a principal engineer and tin whisker expert with French telecommunications equipment maker Alcatel-Lucent SA. "We're solving a problem that isn't and creating a bunch of new ones."

Typically measuring under a millimeter long, tin whiskers look like errant strands of static-charged hair, erupting in every direction from tin-based materials like solder. Their cause is hotly debated. Other metals also grow whiskers, but not like tin.

Trouble arises when the whiskers bridge separate parts of increasingly miniaturized circuit boards. They also can flake off and interfere with sensitive optics.

While scientists debate their cause, they agree on one thing: Small amounts of lead mixed with the tin have been remarkably effective at preventing whisker eruptions for decades.

Lead, however, is a serious health concern. In children, it can cause learning or behavioral problems and has been associated with anemia and kidney problems. In adults, exposure has been linked to high blood pressure and reproductive organ damage.

Last year, Europeans barred the toxic metal from most electronics to prevent its being incinerated or accumulating in dumps after computers and other gadgets are tossed out. Similar measures are being considered or are already in place in other countries, including Japan, China, South Korea, Argentina, Australia and the United States.

Some companies say the EU rules threaten the reliability of their products, exposing them to unknown risks and possibly threatening people's safety.

But EU officials say the regulations banning lead, cadmium, mercury and three other hazardous substances are needed to protect people and the environment.

They also note that many types of electronics are exempt from the law, including military and other national security equipment, medical devices, and servers, data storage computers and telecommunications gear that use leaded solders.

Exemptions are also granted when alternatives to the hazardous materials don't exist yet, or because the substances can't be replaced without jeopardizing safety.

Still, even some companies with exemptions say it's getting harder to buy the leaded parts. They worry about the increased risk of pure-tin parts, the culprit behind the most devastating tin-whisker-related failures.

"Over time (the failures) are just going to get worse and worse and worse," said Jim McElroy, executive director of International Electronics Manufacturing Initiative, or iNEMI, a group of big electronics makers, government agencies and other parties active in tin whisker research.

"Even if the military is exempt forever, they will be forced to convert because they can't get the components they want," he

said. "And that will eventually happen across the board."

Tin whiskers have left a trail of destruction in a string of important machinery, chronicled in an extensive database of publicly disclosed failures kept by researchers at NASA's Goddard Space Flight Center in Greenbelt, Md.

Last year, for example, NASA engineers testing parts for the space shuttle Endeavour discovered that millions of tin whiskers were causing an electronic box to inaccurately point the shuttle's engine, knocking the rocket's trajectory off-kilter, according to Henning Leidecker, chief engineer of the electronic parts office of NASA's Goddard and a tin whisker expert.

It turns out NASA had approved the pure-tin-coated clamps used for holding circuit boards in place back when the electronics were made in the 1980s, before NASA adopted its current rule requiring a small amount of lead in its tin coatings.

"These whiskers have the potential to destroy missions," Leidecker said.

Failures blamed on tin whiskers have run the gamut of devices and manufacturers.

In the 1980s, the U.S. Food and Drug Administration recalled some pacemakers because of a high failure rate caused by tin whiskers.

In 1998, PanAmSat Corp.'s \$250 million Galaxy IV communications satellite, which provided service to tens of millions of pagers across North America and thousands of pay-at-the-pump gas station machines, was deemed a total loss after two processors failed. The main spacecraft control processor, which governs the satellite's positioning and other functions, failed for an unknown reason, and the backup couldn't be used because tin whiskers had shorted it out a year before.

At least 10 other satellite failures have been blamed on tin whiskers, according to the NASA database.

Over the past two decades, also according to the NASA database, nuclear power plants have been temporarily shut down at least seven times after tin whiskers in the alarm system circuit boards triggered false alarms, alerting managers to threats that didn't exist. There have been no reported injuries.

"There's a real loss of money because the plant is shut down and stays down, and it also presents a situation where workers are taught not to believe the alarms," Leidecker said. "Are you comfortable with that? I am not."

The military also isn't immune. Whisker-related malfunctions have been reported in the radar used aboard fighter jets, in the target-detection system of certain missiles, along with various unspecified problems in other parts of the U.S. military's missile programs.

Little is known about those failures, other than the part that failed and the cause. Most involve military secrets and are only known because they're revealed in technical forums by defense contractors, who incur heavy repair expenses for malfunctioning tin-whisker-infested equipment and are active in scientific circles looking for a fix that doesn't involve lead.

Tin whisker experts said the industry is working fast to come up with a lead-free solution. So far, other materials have shown to be effective in preventing tin whiskers, but not as powerfully as lead.

One promising remedy is tin-silver-copper solders, said George Galyon, a senior technical staff member at IBM Corp. However, Galyon noted that lead-free solders often require much higher temperatures, which can warp circuit boards and cause materials to degrade.

Despite the setbacks, he said the major players realize anti-lead laws give them no choice.

"It's whistling in the wind if you think we're turning this back," he said. "China's full-bent on it, the major markets are into it. The world flipped over in one fell swoop."

On the Net:

NASA's Goddard Space Flight Center tin whisker page: <http://nepp.nasa.gov/whisker/>

iNEMI page: <http://www.inemi.org/cms/>

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