Issue 200: Tin Whiskers

DESCRIPTION

Historical Background

This issue was identified by RES after concern was raised for the number of component failures in the solid state protection systems of nuclear power plants that were caused by the growth of tin whiskers.[1]

In 1987, Dresden Nuclear Power Station Unit 2, while in Run Mode at 94% power, experienced a trip of the "B" channel of the RPS because of a high signal on an APRM channel (see LER #87-022-00). The APRM

channels take LPRM output signals as their input. The root cause of the failure was determined to be the growth of metallic whiskers on the fission chamber outer electrode. An arc was generated between electrodes causing a transient short circuit which later burned away. After the whisker melted, the LPRM returned to normal operation.

On April 1, 1990, Duane Arnold Energy Center experienced an automatic reactor scram during reactor startup at 8% thermal power after an increase in flux greater than 15% was observed in APRM channels "C" and "D" (see LER #90-004-00). The intermediate cause of the event was a momentary LPRM spike cause by a transient short circuit between the anode and the cathode in the LPRM detector. This momentary spike in the LPRM output generated an APRM reading indicating a sudden power increase which in turn actuates the RPS logic that generates a scram. After the event, the affected LPRM was bypassed and the plant was started up. This event was not the only one of this nature at this plant. In February 1995, a similar event occurred during a controlled shutdown for a scheduled refueling outage. An upscale APRM reading occurred with the reactor shut down.

In December 1997, also at Dresden Unit 2, an unexpected full reactor scram occurred during an Instrumentation Surveillance due to an unexpected half-scram signal generated after RPS Channel "A" received a spiking LPRM reading in conjunction with an expected RPS Channel "B" half-scram signal (see LER #97-019-00). The unexpected LPRM reading was due to a short circuit caused by a whisker present within the detector. Actions taken after this event included complete I-V plots performance, and LPRM replacement with upgraded types.

On September 1, 1999, at South Texas Project Unit 2, a reactor pre-trip alarm occurred due to a low-low level indication in channel 2 of steam generator 2D while in Mode 1 at 100% power (see LER #1999-006-00). The failure of the input control relay that indicated the low-low level on the steam generator was attributed to tin whiskers. The corrective actions included the replacement of the relay.

On April 17, 2005, Millstone Unit 3 experienced a reactor trip from full power, and one of two trains of the Safety Injection and Main Steam Isolation actuated when low steam line pressure was sensed on one of four steam generators. The cause was the growth of a tin whisker between two components on a Westinghouse SSPS universal logic card, causing a short circuit to ground and triggering the single train of SI and the subsequent automatic reactor trip. A Westinghouse SSPS engineer revealed that the component where the whisker grew was a diode with a blue jacket.

On August 25, 2005, the NRC issued Information Notice 2005-25.[2] which specifically discussed the inadvertent trip at Millstone Unit 3 caused by tin whiskers, notified licensees about recent operating experience related to the growth of tin whiskers in electronic circuits in nuclear power stations, and informed licensees to consider appropriate actions to avoid similar problems.

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[1] Removed

[2] Information Notice 2005-25, "Inadvertent Reactor Trip and Partial Safety Injection Actuation Due to Tin Whisker," U.S. Nuclear Regulatory Commission, August 25, 2005. [ML052150404]

Safety Significance

Tin whiskers are electrically conductive, crystalline structures of tin that can grow from surfaces where tin (especially electroplated tin) is used as a final finish. Tin whiskers can range from several millimeters to as long as 10 mm in length. Their formation in electronic systems has been cited as the root cause for electronic system failure in military aviation and weapons systems, medical equipment, satellites, and in various instances within the electronics and power industries. Electronic component failures caused by tin whiskers have the potential to affect instrumentation and control (I&C) systems in nuclear power plants.

Until recently, this phenomenon has received relatively little attention in the nuclear industry. However, component failures attributed to tin whiskers have occurred at nuclear power plants, ranging in severity from spurious alarms and faulty signals in protection systems to reactor trips.

The use of electroplated tin has been driven by a movement to lead-free products. There is a possibility that the nuclear industry will be increasing the use of commercial off-the-shelf (COTS) -based I&C systems. Although formation of the tin whiskers have the potential to pose safety and reliability issues to all makers and users of high-reliability electronics and associated hardware, the electronics industry and COTS users have experience in documenting and tackling this problem.

Tin whisker incidents in nuclear power plants to date have not been safety significant. There have been no Accident Sequence Precursor (ASP) events, no impairment of redundant safety functions, no CCF events, no increasing trend of recent events, and no apparent decrease in reliability of systems/components due to tin whiskers. Lastly, this issue falls within the scope of the maintenance rule and no new rule/regulation is apparently needed.

Possible Solution

If the issue does not meet the criteria for pursuit, it could be dropped or be pursued as a compliance issue, as warranted. If further study is needed to better understand and establish the technical basis and safety impact of tin whiskers, NRR could make use of the User Need process to request RES assistance.

CONCLUSION

The low number of reported events associated with this issue, the lack of any increasing trend, the lack of any apparent decrease in reliability of systems or components due to tin whiskers, the existence of applicable regulatory requirements and programs (i.e., 10 CFR Part 21, the maintenance rule requirements, and the

Reactor Oversight Program), and the issuance of Information Notice 2005-25[3] to alert licensees collectively indicated that tin whiskers did not meet the requirements of NRC Management Directive 6.4. "Generic Issues Program," for further pursuit. Based on the considerations discussed above, RES recommended that the issue be returned to the originator to be evaluated for other possible options. As a result, the issue was DROPPED

from further pursuit.[4]

[3] Information Notice 2005-25, "Inadvertent Reactor Trip and Partial Safety Injection Actuation Due to Tin Whisker," U.S. Nuclear Regulatory Commission, August 25, 2005. [ML052150404]
[4] Removed