UNITED STATES
NUCLEAR REGULATORY COMMISSION
OFFICE OF NUCLEAR REACTOR REGULATION
WASHINGTON, D.C. 20555

August 25, 2005

NRC INFORMATION NOTICE 2005-25: INADVERTENT REACTOR TRIP AND PARTIAL SAFETY INJECTION ACTUATION DUE TO TIN WHISKER

ADDRESSEES

All holders of operating licenses for pressurized-water reactors (PWRs) and boiling-water reactors (BWRs) except those who have permanently ceased operations and have certified that fuel has been permanently removed from the reactor vessel.

PURPOSE

The U.S. Nuclear Regulatory Commission (NRC) is issuing this information notice to inform addressees about recent operating experience related to the growth of “tin whiskers” in electronic circuits at nuclear power stations. Recipients are expected to review the information for applicability to their facilities and consider appropriate actions to avoid similar problems. However, the measures suggested in this information notice are not NRC requirements and no specific action or written response is required.

DESCRIPTION OF CIRCUMSTANCES

On April 17, 2005, Millstone Nuclear Generating Station, Unit 3, experienced an unexpected safety injection actuation and reactor trip caused by a fault on a solid state protection system (SSPS) circuit card. The fault generated a false low steamline pressure signal, bypassing the 2-out-of-3 SSPS logic and causing the A safety train actuation and reactor trip. The licensee examined the failed circuit card using a magnifying glass and found a microscopic tin filament (approximately 2 mm long). The filament created a bridge between the affected diode and the output trace on the card. This microscopic filament of tin called “tin whisker,” had grown out of the tin coating covering the leads of the diode.

The licensee inspected all circuit cards in the SSPS and discovered tin whiskers on other circuit cards. In each case, the whisker appeared to originate at the tin coating on diode leads. Suspect cards were either replaced or cleaned before being placed back in service. The licensee sampled additional circuit cards from other important plant systems but found no other evidence of tin whiskers.

BACKGROUND

Tin whiskers are electrically conductive crystalline structures of tin that sometimes grow from surfaces where pure tin (especially electroplated tin) is used as a final finish. Tin whiskers have

been observed to grow to lengths of several millimeters (mm) and in rare instances up to 10 mm. Electronic system failures have been attributed to short circuits caused by tin whiskers that bridge closely spaced circuit elements maintained at different electrical potentials.

Tin whiskers appear to have increased following international efforts to remove alloying metals such as lead from solder and other circuit card manufacturing materials to reduce environmental and health hazards. With the move toward lead-free electronics, tin has become a drop-in replacement for the tin-lead finish currently used for electrical component terminations. The move to lead-free electronics means that failures of some high-reliability components may continue to increase until a solution to the tin whiskers problem is found. Tin whiskers have been cited as the cause for various minor component failures in the nuclear industry and significant failures in the aerospace industry.

DISCUSSION

Some of the failures due to whiskers are documented in licensee event reports (LERs):

Plant	LER No.	NUDOCS Accession No.
Dresden Unit 2	50-237/1987-22	8709230145
Duane Arnold	50-331/1990-04	9005010072
Dresden Unit 2	50-237/1997-19	9801270112
South Texas Unit	50-499/1999-06	9910080186

In most of the events, metallic whiskers caused a short of the local power range monitors (LPRM) detectors resulting in a momentary spike on the average power range monitors (APRMs). In other cases, whiskers resulted in a failure of a channel input relay to the engineered safety features (ESF) actuation logic. In most cases, failure of the channel inputs in to the reactor protection system (RPS) or the ESF actuation did not result in a full RPS or ESF actuation. Only half of the RPS or ESF logic was met.

The incident at Millstone Unit 3 demonstrates that a single tin whisker can cause a protective feature to actuate. It is reasonable to assume that the same phenomenon could also prevent a protective system actuation. The extent-of-condition review performed at Millstone also showed that circuit cards need not be in service to be susceptible to whiskering. Research available from NASA's Goddard Space Center (http://nepp.nasa.gov/whisker) and Computer Aided Life Cycle Engineering (CALCE) at the University of Maryland supports this discovery and provides other valuable information on prevention techniques and growth mechanisms. While the information provided directly states that the exact mechanism for growth is unknown, common growth conditions and theories are discussed.

The data from the extent-of-condition review at Millstone Unit 3, NASA and CALCE information indicate that more than one manufacturer makes high-reliability circuit cards susceptible to tin whiskering. The data also indicates that tin whiskering is not significantly influenced by the environment in which the cards are used. Therefore, if one card procured from a specific vendor shows evidence of whiskering, all cards of that type from the same manufacturer can be

expected to show signs of whiskering. In general, components containing 3% or greater lead concentration in the solder and/or manufactured with conformal coatings appear to be less susceptible to tin whiskering.

CONTACTS

This information notice requires no specific action or written response. Please direct any questions about this matter to the technical contacts listed below or the appropriate Office of Nuclear Reactor Regulation (NRR) project manager.

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Note: NRC generic communications may be found on the NRC public Web site, http://www.nrc.gov, under Electronic Reading Room/Document Collections.

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