Westinghouse Electric Company

Technical Bulletin

An advisory of a recent technical development pertaining to the installation or operation of Westinghouse-supplied nuclear plant equipment. Recipients should evaluate the information and recommendation, and initiate action where appropriate.

P.O. Box 355, Pittsburgh, PA 15230

Subject: **Potential Tin Whiskers on Printed Circuit Board Components**	Number: **TB-05-4**
System(s): Various	Date: 06/08/2005
Affected Plants: All Plants	S.O.: Various
References: See Page 4	Affects Safety Related Equipment Yes ☒ No ☐

INTRODUCTION

On April 17, 2005, a unit tripped when train A of the solid state protection system (SSPS) inadvertently generated a safety injection signal at full power operation. The cause of the trip was attributed to the failure of a universal logic board located in the SSPS. The board failure was subsequently determined to be caused by a short from the anode lead of diode CR47 to the printed circuit board trace directly beneath it. The short was caused by a "tin whisker", a condition where a small whisker sprouts from a component that contains high amounts of pure tin (in this case the lead of the diode) and like a crystal, the whisker grows over time. The trace beneath the diode provides one of three outputs from the board and in this case was shorted to ground causing a demand for safety injection from the train. This event and subsequent evaluations are documented in References 1 and 2.

BACKGROUND

Certain metals such as tin, zinc, cadmium, and silver have been observed to grow metallic filaments called whiskers. Tin whiskers are electrically conductive, crystalline structures that could randomly grow from any tin plated component or surface. Tin whiskers have been observed to grow to lengths of several millimeters (mm) and in rare instances up to 10 mm in length. Typically, an alloy (e.g. lead) is added to tin used in electroplating to inhibit the growth of whiskers. Significant background information regarding metallic whiskers may be found at the following web site maintained by the NASA Goddard Space Flight Center, http://nepp.nasa.gov/whisker.

Additional information, if required, may be obtained from Bill Miller (724) 733-6298 or Tom Harbaugh (724) 722-5430

Originator:(s)

W. J. Smoody
Regulatory Compliance and Plant Licensing

Approved:

J. A. Gresham, Manager
Regulatory Compliance and Plant Licensing

The diodes observed with tin whiskers on the SSPS universal logic board are manufactured to Mil-Spec MIL-PRF-19500/117. This Mil-Spec through a referenced generic Mil-Spec (MIL-PRF-19500) requires that the component's leads be coated with tin containing a minimum amount of another alloy to prevent whiskers. The standard reads "Tin based coatings shall be alloyed with a minimum of 3 percent of a second metal (e.g. lead) which has been shown to inhibit the growth of tin whiskers." It is suspected that diodes seen with whiskers have a coating on the leads that is too pure resulting in the growth of the tin whiskers.

In Reference 2, tin whiskers are reported to have been observed on both the SSPS universal logic boards and safeguards driver boards. The components seen with tin whiskers are zener diodes with part number JAN1N980B. These Mil-Spec parts may have been supplied from any one of the suppliers on the Mil-Spec's Qualified Manufacturer's List. Diodes from four of the different approved suppliers have been known to be used over the years for this part as follows:

Clear case – Motorola
Black case – National Semiconductor
Light blue case – International Rectifier
Dark blue case – Microsemi

The inspections documented in Reference 2 indicate that tin whiskers were observed on diodes with clear cases (Motorola) and light blue cases (International Rectifier). In general, the tin whiskers were observed on more diodes supplied by International Rectifier and in these cases the whiskers tended to be more predominant. The tin whiskers were observed on printed circuit boards of various vintages as indicated by serial numbers in the 2000, 3000, 4000 and 6000 series.

A number of utilities have performed partial or complete inspections of printed circuit boards located in their SSPS during the recent spring outage period. Utilities have reported either no whiskers or minimal whiskers as a result of these inspections. Reference 3 documents the findings of one utility's inspections of the SSPS while most of these inspections were informally reported back to Westinghouse.

Numerous electronic system failures have been attributed to short circuits caused by tin whiskers that bridge closely-spaced circuit elements maintained at different electrical potentials. INPO Topical Report TR5-47 (Reference 4) notes that tin whiskers were first identified as the cause of a plant trip in 1994 at an international nuclear station. Information related to this event can be obtained at entry 944-940126-1 in INPO's International Database. The recent event documented by References 1 and 2 is the only other known plant trip related to tin whiskers.

Tin whiskers, resulting in minimal plant impacts, have been observed and reported in several other instances in the nuclear industry. Westinghouse issued Technical Bulletin TB-02-5 (Reference 5) in July, 2002 to provide notification of tin whiskers observed in power supplies manufactured by Basler Electric and used in the SSPS and digital rod position indication system. Foxboro, in July, 1999, issued a 10CFR21 notification (1999-35) regarding tin whiskers observed in printed circuit board mounted relays (Reference 6).

SAFETY SIGNIFICANCE

The observed random growth of tin whiskers can cause unintended reactor trips or engineered safeguards actuation (e.g. safety injection). These transients are within the design basis transients and accident analyses of the plant. Through periodic testing, and enhanced inspection and removal procedures for tin whiskers, these transients and the associated cycling of components and systems can be avoided.

There is a potential that a reactor trip could be blocked (shorted) due to the random growth of tin whiskers. The probability of this occurring is highly unlikely since the same trip function in both trains would have to short at the same time that a protective trip function is required in order to actually block the reactor trip. It would be highly unlikely that both trains providing the same reactor trip function would be affected at the same time since the actual start of whisker growth would not be the same in both trains. Shorting due to tin whiskers would be detected during periodic testing and visual inspection of protection system printed circuit boards. Removal of tin whiskers is sufficient to eliminate any operational concerns between periodic testing. Therefore, this issue does not represent a condition adverse to safety and is not reportable to the NRC pursuant to the requirements of 10 CFR21.

SYSTEMS AFFECTED

Based on the potential for tin whiskers to grow on electronic components coated with tin (e.g. PC boards, relays, etc), utility inspections for whiskers and preventative maintenance activities should not be limited to just the SSPS. It is recommended that utilities evaluate their safety systems and control systems that are considered critical to plant operations (e.g. rod control, feedwater control, and turbine control) for tin whiskers.

RECOMMENDED ACTIONS

Westinghouse recommends that utilities conduct periodic inspections for tin whiskers beginning with the next planned outage. In order to detect the presence of tin whiskers, the inspections should be done with a minimum of 10x magnification and directed light. A higher magnification factor will make identifying whisker growth easier. Utilities that have performed inspections during the spring outage season have indicated that both light and the magnification level are critical to observing whiskers since whisker diameters are typically in the range of 1 to 2 microns and are difficult to see under normal conditions. An inspection of a 15% random sample of installed components is recommended to ensure an adequate population is inspected and to minimize the adverse affects of handling and temperature cycling. If any of the randomly selected components have tin whiskers, 100% inspection of the components installed in the system is recommended.

Upon completion of the inspection, the components should be gently cleaned with a soft bristle, static-free brush and cleaned with either canned air or a static-free vacuum.

Westinghouse recommends that the inspections be performed periodically at least every 5 to 6 years, depending on the operating unit's refueling cycle. Utilities may elect to systematically spread the inspections of affected systems across several outages to optimize planned maintenance activities.

REFERENCES

1. INPO OE20450 – "Millstone Unit 3 Automatic Reactor Trip (updated by OE20450)", May 23, 2005

2. INPO OE20688 – "Update to OE20540 – Extent of Condition Review Identifies Defects on SSPS Circuit Cards at Millstone 3", May 19, 2005

3. INPO OE20650 – "Tin Whisker Found On SSPS Card", May 18, 2005

4. INPO Topical Report TR5-47 – "Review of Circuit Card/Board Related Failures That Contributed to Automatic and Manual Scrams (Addendum to TR5-43)", May, 2005

5. TB-02-5 – "Basler Power Supplies", July 12, 2002

6. 10CFR21 Report 1999-35 – "Tin Whiskers on Relay Contact Support Arms", July 9, 1999