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October 5, 2016 RSC 1281

U.S. Nuclear Regulatory Commission
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Washington, D.C. 20555-0001

Subject: Response to NRC Generic Letter 2016-01 from the University Of Wisconsin Nuclear Reactor Docket 50-156, License R-74

In response to NRC Generic Letter 2016-01, Monitoring of Neutron-Absorbing Materials in Spent Fuel Pools, dated April 7, 2016, the University of Wisconsin Nuclear Reactor (UWNR) is providing the following information regarding the reliance on neutron-absorbing materials for nuclear criticality safety of reactor fuel in storage contained within the reactor pool.

As described in section 9.2.2 of the Safety Analysis Report for the University of Wisconsin Nuclear Reactor, revision 3, fuel storage locations within the reactor pool consist of three aluminum racks attached to the pool wall and three aluminum fuel storage baskets located in the fuel storage pit in the bottom of the pool.

The aluminum racks attached to the pool wall (hereinafter referred to as "wall racks"), do not contain any neutron absorbers. The geometry of the wall racks maintain the effective neutron multiplication factor to less than 0.8.

The aluminum fuel storage baskets located in the fuel storage pit (hereinafter referred to as "pit baskets") are constructed with aluminum clad metallic cadmium poison plates. Each basket is a 4 by 5 array incorporating 8 cadmium poison plates that are nominally 16 inches by 30 inches by 0.040 inch sandwiched between two nominal 0.090 inch thick aluminum plates with welded seams. Four cadmium poison plates are incorporated into the side walls of the pit basket and the remaining four plates separate the rows. Fuel is not routinely stored in the pit baskets. The baskets are available as a shielded fuel storage location, as the fuel storage pit incorporates a 6 inch thick aluminum clad lead cover.

Analysis has shown, that by geometry alone, the pit baskets maintain subcritical the entire fuel inventory at the facility when off loaded to the fuel storage pit. However, in order to achieve

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an effective neutron multiplication factor of less than 0.8, credit is taken for 5% of the cadmium physically present in the baskets.

The monitoring program used to confirm continued acceptable performance of the neutron absorbing material at the facility consists of visual inspections of the pit baskets as well as blackness testing and/or nuclear criticality measurements. Specifically, prior to use the pit baskets are visually inspected for physical damage that might have mechanically displaced the poison plates. Additionally, the poison plates are visually inspected every five years to verify the integrity of the clad and welded seams, independent of whether the baskets are intended to be used or not. Finally, at a frequency of every 15 years, blackness testing and/or nuclear criticality measurements are conducted to ensure the effectiveness of the cadmium as a neutron absorber. Blackness testing consists of placing a neutron emitting source in each storage basket location and measuring the transmission of the neutrons with a neutron sensitive detector. Nuclear criticality measurements consist of actually loading fuel into the pit baskets while monitoring neutron count rate and generating inverse count rate ratio curves to predict criticality, or more accurately, to confirm sub criticality.

The technical basis for the monitoring program is based on the means by which a decrease in effectiveness of the cadmium poison plates could occur. Specifically, the loss of the cadmium due to mechanical displacement or corrosion.

If the cadmium plates were to be mechanically damaged or physically missing the possibility exists that the remaining poison plates would not provide the licensing basis margin to criticality and therefore a visual inspection of the plates prior to use would confirm the presence of the poison plates.

Other means by which a decrease in effectiveness of the cadmium poison plates could occur include corrosion of the cadmium. Cadmium forms a protective oxide film in air to produce cadmium oxide, CdO, which reduces its corrosion/oxidation rate. Cadmium oxide is insoluble in water but will dissolve in weak acids[1]. Therefore, no credit is taken for the protective cadmium oxide layer. In acidic aqueous solutions metallic cadmium will dissolve as Cd^{2+}ions. In highly alkaline solutions dissolution of cadmium occurs due to the production of the soluble $HCdO_2^-$ ion. Corrosion rates of metallic cadmium in aqueous solutions as a function of pH have been well documented[2]. In measurement using distilled water, dissolution rates of 5 to 19mg/dm^2-d have been measured. In relative terms, with respect to the poison plates, this would be equivalent to 4.1% to 15.8% loss per year.

Additionally, while the free galvanic corrosion potentials of cadmium and aluminum are similar, a galvanic couple between the dissimilar metals is possible. Dissolution rates as a result of galvanic couples between cadmium and aluminum have been measured[3] to be as high as 4 mg/dm^2-d. In relative terms, this would be equivalent to 3.3% loss per year. However in order for a galvanic couple to occur between the dissimilar metals the metals must be subject to an electrolytic environment.

Because of the existence of the aluminum clad, it is not possible to assess the effects of corrosion of the cadmium. However as discussed above, the dissolution of cadmium requires an aqueous environment and specific to the potential for galvanic corrosion an electrolytic aqueous solution. Therefore the monitoring program includes a visual inspection of the poison plates' clad and welded seams. If the clad and welds show no indication of deterioration than it is concluded that the cadmium is not subject to an aqueous environment and therefore there is no opportunity for corrosion to occur. This inspection occurs at a frequency of once every 5 years. The frequency of this inspection is based on an extremely aggressive dissolution rate, as applied to the reactor pool environment, of 19 mg/dm^2-d. The strict chemistry and resistivity control of the reactor pool water precludes the existence of an electrolytic environment and therefore the dissolution rate of a galvanic couple is neglected. With a conservative dissolution rate of 19 mg/dm^2-d, it would take 5.99 years for 95% of the cadmium to dissolve. Recall only 5% is credited in the analysis. Furthermore this assumes that all the poison plates' clad and welded seams have failed which is deemed not credible within a 5 year period.

Finally, to account for the potential of a clad or weld failure going undetected during the 5 year visual inspections, a blackness test and/or nuclear criticality measurement is conducted in order to confirm the effectiveness of the neutron absorber every 15 years. The basis for the frequency of this inspection is the arbitrary assumption that two poison plates have failed and gone undetected and the cadmium is subject to corrosion after each 5 year inspection. As a result, 95% of cadmium could deteriorate between the 3rd and 4th 5-year inspections.

I certify under penalty of perjury that the foregoing is true and correct.

Sincerely,

Robert J. Agasie
Reactor Director

Executed on: 10/5/2016

References

[1] Morrow, H. 2010. Cadmium and Cadmium Alloys. Kirk-Othmer Encyclopedia of Chemical Technology. 1–36.

[2] Tomlinson, W.J.; Wardle, N. Electrochemical Equilibria of Cadmium and Water and the Dissolution of Cadmium as a Function of pH. *Corrosion Science*, 1975, vol 15, pp 663-665.

3 F. Mansfeld, D. H. Hengstenberg, J. V. Kenkel, Galvanic Corrosion of Al Alloys I. Effect of Dissimilar Metal, *Corrosion*, 1974, vol 30, pp 343-353.