UNITED STATES
NUCLEAR REGULATORY COMMISSION
OFFICE OF NUCLEAR REACTOR REGULATION
OFFICE OF NEW REACTORS
WASHINGTON, DC 20555-0001

January 15, 2016

NRC INFORMATION NOTICE 2016-02: IMPROPER SEATING OF REACTOR VESSEL SURVEILLANCE CAPSULES

ADDRESSEES

All holders of an operating license or construction permit for a nuclear power reactor under Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50, "Domestic Licensing of Production and Utilization Facilities," except those that have permanently ceased operations and have certified that fuel has been permanently removed from the reactor vessel.

All holders of and applicants for a combined license, standard design approval, or manufacturing license under 10 CFR Part 52, "Licenses, Certifications, and Approvals for Nuclear Power Plants." All applicants for a standard design certification, including such applicants after initial issuance of a design certification rule.

PURPOSE

The U.S. Nuclear Regulatory Commission (NRC) is issuing this information notice (IN) to inform addressees of recent operating experience related to reactor vessel surveillance capsules that were not properly seated in their baskets and subsequently broke loose during plant operation. This resulted in the generation of over 200 loose parts in the reactor vessel that adversely affected some in-vessel components.

The NRC expects that recipients will review the information for applicability to their facilities and consider actions, as appropriate, to avoid similar problems. However, suggestions contained in this information notice are not NRC requirements; therefore, no specific action or written response is required.

DESCRIPTION OF CIRCUMSTANCES

During a refueling outage in April 2015, Sequoyah Nuclear Plant (Sequoyah) identified the presence of over 200 loose parts in the Unit 1 reactor vessel. The loose parts consisted of two broken surveillance capsules and their contents. Sequoyah reported the condition to the NRC on August 7, 2015, in Event Report 51298, in accordance with 10 CFR 21.21, "Notification of failure to comply or existence of a defect and its evaluation," which describes notification requirements for defects associated with a condition that, if left uncorrected, could create a substantial safety hazard. In addition, this issue was dispositioned as a Green finding with an associated non-cited violation in Section 4OA2 of Inspection Report 05000327/2015003;

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05000328/2015003, "Sequoyah Nuclear Plant – NRC Integrated Inspection Report" (Agencywide Documents Access and Management System (ADAMS) Accession No. ML15313A244).

The reactor vessels at the two-unit Sequoyah plant each had eight surveillance capsules that were installed inside the vessels during plant construction. The eight surveillance capsules were located in alphabetically-labeled locations (S, T, U, V, W, X, Y, and Z). The surveillance capsules contain specimens of the material that the reactor vessel was constructed from, which the facility periodically removes to test for neutron embrittlement effects on reactor vessel material properties. Sequoyah previously withdrew and tested four of the eight Unit 1 surveillance capsules (from the T, U, X and Y locations) in order to fulfill the surveillance capsule withdrawal requirements of 10 CFR 50, Appendix H, "Reactor Vessel Material Surveillance Program Requirements," for a 40-year end-of-life period (32 effective full-power years). As part of the license renewal effort for both Sequoyah units, the licensee determined that it should relocate two of the remaining four irradiated surveillance capsules from their original locations to higher fluence locations within the reactor vessel.

Sequoyah relocated the two Unit 1 surveillance capsules during a refueling outage in November 2013. The surveillance capsule in location S was moved to location T, and the surveillance capsule in location W was moved to location X. Following plant startup, the licensee determined that a loose part or multiple loose parts were present in the Unit 1 reactor vessel, based on abnormal acoustic signals from the loose parts monitoring system. The licensee continued to monitor the abnormal acoustic signals over the course of the operating cycle and determined that the size of the object(s) decreased, while the frequency of acoustic indications increased.

During the next refueling outage in April 2015, the licensee determined that the source of the loose parts was the two irradiated surveillance capsules that had been relocated during the prior refueling outage. The capsules were not properly seated in the storage baskets during relocation and became dislodged from the baskets during plant operation. This resulted in over 200 loose pieces of capsules, spacers, instrumentation parts, and irradiated specimens inside the reactor vessel upstream of the fuel assembly nozzles. The licensee removed the loose parts from the vessel and the core barrel, lower internals, and lower vessel head. Minor wear on vessel internal components was identified. Prior to plant startup, the licensee replaced two fuel assemblies due to damage to the fuel assembly nozzle filter screens.

BACKGROUND

In accordance with Appendix H of 10 CFR Part 50, licensees of reactor vessels with end-of-design life neutron fluences that exceed 1.0E17 n/cm^2 (E>1 MeV) must monitor their beltline materials through a surveillance program. The purpose of these programs is to monitor changes in the fracture toughness properties of the ferritic materials in the reactor vessel beltline regions that result from exposure of these materials to neutron irradiation and the thermal environment. Under the program, surveillance capsules are located in each vessel between the core and the reactor vessel in close proximity to the beltline region.

The types of material specimens contained in the surveillance capsules include Charpy specimens, tensile specimens, and (optional) compact fracture toughness specimens. Since the surveillance capsules are located closer to the core, they receive higher levels of neutron fluence than the reactor vessel. This increase is referred to as the lead factor. The higher levels of neutron irradiation received by the surveillance capsule specimens provides insight to

projected changes in the fracture toughness properties of the reactor vessel. The surveillance capsules are designed and located to permit the relocation or insertion of replacement capsules, and capsules may be moved to optimize lead factors.

Licensees periodically withdraw and test surveillance capsules in accordance with the approved withdrawal schedule and the requirements of Appendix H of 10 CFR Part 50. Appendix H of 10 CFR Part 50 states, in part, that "…the withdrawal program must meet the requirements of the Edition of ASTM E 185 [American Society for Testing and Materials E 185, "Standard Practice for Design of Surveillance Programs for Light-Water Moderated Nuclear Power Reactor Vessels"] that is current on the issue date of the ASME Code to which the reactor vessel was purchased. Later editions of ASTM E 185 may be used, but including only those editions through 1982." Capsules beyond the minimum number of capsules described in Table 1 of ASTM E 185-82 are designated as standby capsules in the 10 CFR Part 50, Appendix H program for the original licensed operating period.

License renewal and the period of extended operation are discussed in section XI.M31, "Reactor Vessel Surveillance," of NUREG-1801, "The Generic Aging Lessons Learned (GALL) Report," Rev. 2, dated December 2010 (ADAMS Accession No. ML103490041). This section states that one surveillance capsule should be withdrawn at an outage in which the capsule receives a neutron fluence of between one and two times the peak reactor vessel wall neutron fluence at the end of the period of extended operation and be tested in accordance with ASTM E 185-82. Therefore, upon receiving a renewed operating license, some surveillance capsules previously considered as standby capsules may no longer be considered standby capsules; instead, they would be considered part of the Reactor Vessel Surveillance program to meet the NUREG-1801, GALL Report guidelines and the 10 CFR Part 50, Appendix H requirements.

DISCUSSION

The licensee determined that the two irradiated surveillance capsules had not been properly seated in their storage baskets when they were relocated during the 2013 refueling outage, which allowed them to become dislodged from the baskets during plant operation. Two root causes for the event were identified: (1) the use of unapproved actions during relocation of the capsules, and (2) an inadequate procedure to verify proper capsule seating after relocation.

During the removal of access plugs in preparation for relocation of the surveillance capsules, workers elected to use an alternate tool since the pneumatic tool that was designed for the task was unreliable. This represented a deviation from procedure, but was not recognized at the time. The new location for a surveillance capsule was required, by procedure, to be cleaned under observation via a camera from an adjacent location. When the camera was installed in the closest adjacent location, workers discovered that the location being cleaned was not visible from the camera. The procedure was not revised and there was no documentation of this issue at the time. Procedural guidance for relocation of the surveillance capsules directed the use of the pneumatic tool and observation by camera from an adjacent location.

When the capsules were relocated, the alternate tool was used rather than the pneumatic tool and, similar to the cleaning evolution, installation of the capsule in the new location was not visible from the camera. Rather than viewing the actual seating of the surveillance capsules, workers used a camera after the tool was removed to check that the capsules were seated. The procedure was not changed to reflect these actions and the deviation from procedure was not documented. After the capsule was placed in the new location, procedure directed use of the loading tool which presses the capsule into place, be monitored via camera from an

adjacent location. Again, the procedure could not be accomplished, as written, since the location was not visible from the camera, and there was no revision to the procedure or documentation of the deviation.

The procedure included three criteria to monitor for proper capsule seating: (1) hydraulic pump pressure, (2) observation of how far recessed into the basket the capsule's top plug is, and (3) observation of the spacing of the capsule's top plug. The crew did not observe the expected hydraulic pump pressure, but implemented an alternate method allowed by the procedure. Since the seated capsule could not be viewed by camera from the adjacent location, the crew inserted the camera from directly above each relocated surveillance capsule, which did not provide a view of how far seated (recessed) into the basket the surveillance capsules were. The crew ultimately determined that the relocated surveillance capsules were properly seated.

The root cause evaluation noted that the pump pressure criteria in the procedure might not be an adequate measure of proper seating, whereas the amount a surveillance capsule is recessed into the basket is a more definitive measure of proper seating. Additionally, spacing of the top plug is the same for a properly seated capsule as it is for one that is simply resting on the basket. Thus, two of the three procedure criteria for proper surveillance capsule seating were not adequate, and the procedure did not include an accurate way to measure how far the top plug was recessed into the basket.

Several contributing causes were also identified. Field oversight of the work activity was inadequate in that there were a number of missed opportunities to identify that the work deviated from procedure. The work activity could have been conservatively characterized as high risk rather than low risk, which would have resulted in additional reviews before work was started and the development of actions to mitigate potential risks. The behaviors associated with oversight and risk characterization of the work activity were not reflective of the safety culture traits defined in Inspection Manual Chapter 0310, "Aspects Within the Cross-Cutting Areas." Corrective actions to preclude repetition included enhanced oversight requirements and inclusion of a physical pull-test for relocated capsules, in addition to visual verification of proper surveillance capsule seating.

Licensees may determine that reactor vessel surveillance capsules must be relocated. This operating experience discusses the importance of proper planning, execution, verification, and oversight for such an activity. If not properly planned, executed, and verified, relocation of reactor vessel surveillance capsules can result in loose parts in the reactor vessel and damage to reactor vessel internals, including nuclear fuel assemblies.

CONTACTS

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

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