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

February 24, 2004

# NRC INFORMATION NOTICE 2004-04: FUEL DAMAGE DURING CLEANING AT A FOREIGN PRESSURIZED WATER REACTOR

Addressees:

All holders of operating licenses for light-water reactors, except those who have permanently ceased operations and have certified that fuel has been permanently removed from the reactor.

Purpose:

The U.S. Nuclear Regulatory Commission (NRC) is issuing this information notice to inform addressees about a recent fuel damage event that occurred during chemical cleaning of the fuel at a foreign pressurized-water reactor (PWR). The fuel cleaning system involved in the event was not of domestic (U.S.) design or manufacture; however, the fuel and processes used at the affected PWR are similar to those that may be used in domestic light-water reactors. This event involved a release of radioactive material to the environment and was publicly reported in the news media. The occupational dose to workers was well within regulatory limits, and the estimated dose to members of the public was a small fraction of regulatory limits and less than 1 day's exposure to natural background radiation. The event was classified as Level 3 on the International Nuclear Event Scale, based on substantial damage to irradiated fuel.

The NRC expects recipients to review the information in this notice for applicability to their facilities and consider actions, as appropriate, to avoid similar problems. However, suggestions contained in this information notice do not constitute NRC requirements and, therefore, do not require any specific action or written response.

Description of Circumstances:

The event in question occurred at a foreign PWR that was undergoing chemical cleaning of the fuel because the reactor had experienced corrosion product deposition that affected core thermal performance. This corrosion product deposition was attributable to a variety of factors, including earlier steam generator chemical decontamination. The plant's management elected to conduct the chemical cleaning, which was originally scheduled to take place during an upcoming refueling outage to improve core thermal performance during the subsequent operating cycle.

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The facility had received licensing approval for the fuel cleaning system, based in part on previous successful cleaning of seven-assembly batches of fuel that had decayed for more than a year. The operator installed the fuel cleaning system in the cask transfer area adjacent to the spent fuel pool. The fuel cleaning system consisted of a large tank designed to hold 30 fuel assemblies, other tanks to hold and collect the cleaning solution, pumps to circulate the cooling water and cleaning solutions, filters to trap removed corrosion products, and valves and hoses to control and direct the flow of the cleaning solution. The tank containing the fuel assemblies was insulated to facilitate the maintenance of temperatures to support the cleaning process. Openings in the top of the tank consisted only of a small line to vent noncondensible gases and a covered access opening to permit movement of the fuel assemblies. (The latter opening was closed during the cleaning process.) The cooling flow entered the bottom of the tank, flowed up through the fuel assemblies, flowed down around the shroud surrounding each assembly, and exited the tank through a plenum at the bottom. However, bypass flow paths reduced the effectiveness of the available cooling flow. The flow during the cleaning process was high, but the standby cooling pump used after completion of the cleaning cycle produced much lower flow.

Following reactor shutdown on March 29, 2003, the reactor operator began fuel cleaning operations with fuel removed from the reactor vessel. The operators successfully cleaned three batches of recently irradiated fuel without incident. However, unlike the earlier batches, the operators did not remove the tank access cover shortly after the completion of the cleaning process for the fourth batch on April 10, 2003, because the crane was being used for another task. The 30 fuel assemblies in the tank represented about 10 percent of the core and had an estimated decay heat rate of 240 to 270 kW. Analyses later demonstrated that the single cooling pump in operation after the completion of the cleaning process provided insufficient flow to effectively cool the fuel assemblies with the access cover in place because bypass flow paths and the development of a negative thermal head precluded upward flow through the fuel assemblies.

The decay heat began producing steam within the cleaning tank. Because the vent line was inadequate for the rate of steam generation, the steam displaced the water surrounding the fuel assemblies within several hours. In a steam environment, the fuel temperature increased rapidly to an estimated 1,200 Kelvin. This temperature increase caused a minor release of noble gases from the fuel assemblies, which was detected by plant instruments. In response to this release, plant operators decided to remove the cleaning tank access cover. The absence of instrumentation within the cleaning tank precluded the assessment of conditions within the cleaning tank prior to removal of its access cover. When the access cover seal was broken early in the morning of April 11, 2003, water entered the tank and contacted the hot fuel assemblies. Subsequent video examination of the cleaning tank revealed severe fuel damage that resulted from the water quenching of the hot fuel assemblies and their surrounding shroud. The operator estimated that this fuel damage event resulted in the release of a few hundred Tera Becquerels (about 10,000 Curies) of nobel gases, a few tenths of a Tera Becquerel (about 10 Curies) of radioiodine, and less than one-hundredth of a Tera Becquerel (about a quarter of a Curie) of other particulate radionuclides (principally Cesium isotopes). Offsite environmental measurements were consistent with these release estimates.

The failure of the fuel cladding and surrounding shroud resulted in a redistribution of fuel material, with much of it settling to the bottom of the cleaning tank. This distribution of fuel material was outside the configurations analyzed to verify a substantial margin to criticality. To ensure an adequate margin to criticality, the operators substantially increased the dissolved boron concentration in the spent fuel pool and adjacent cask transfer pit.

Discussion:

Provision of adequate cooling, maintenance of a margin to criticality, and maintenance of fuel integrity for fission product retention are essential functions for the safe storage of irradiated fuel. These functions are normally accomplished through passive design features incorporated in the design of the fuel and the storage racks.

This event demonstrates the importance of maintaining adequate cooling of fuel after discharge from the reactor vessel. In this event, the design features that provide adequate natural circulation cooling were not maintained in the design of the cleaning system. Instead, the cleaning system design relied on forced circulation cooling without adequate consideration of the reliability and capability provided for this function. The damage to the integrity of the fuel, which resulted from the inadequate cooling, threatened the maintenance of an adequate margin to criticality and released a substantial quantity of radioactive material to the environment.

Related Generic Communications:

The following NRC generic communications describe related reactor operating experience:

(1) Information Notice 97-85, "Effects of Crud Buildup and Boron Deposition on Power Distribution and Shutdown Margin," December 11, 1997.

(2) Information Notice 97-14, "Assessment of Spent Fuel Cooling," March 28, 1997.

(3) Generic Letter 88-17, "Loss of Decay Heat Removal 10 CFR 50.54(f)," October 17, 1988.

(4) Generic Letter 87-12, "Loss of Residual Heat Removal (RHR) while the Reactor Coolant System (RCS) is Partially Filled," July 9, 1987.

This information notice does not require any specific action or written response. If you have any questions about the information in this notice, please contact one of the technical contacts listed below or the appropriate project manager in the NRC's Office of Nuclear Reactor Regulation.

***/RA/***
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|---|---|---|---|
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| 2004-02 | Strontium-90 Eye Applicators New Calibration Values and Use | 02/05/2004 | All U.S. Nuclear Regulatory Commission (NRC) medical-use licensees and NRC master materials license medical-use Permittees. |
| 2004-01 | Auxiliary Feedwater Pump Recirculation Line Orifice Fouling - Potential Common Cause Failure | 01/21/2004 | All holders of operating licenses or construction permits for nuclear power reactors, except those that have permanently ceased operations and have certified that fuel has been permanently removed from the reactor. |
| 2002-26, Sup 2 | Additional Failure of Steam Dryer After A Recent Power Uprate | 01/09/2004 | All holders of an operating license or a construction permit for nuclear power reactors, except those that have permanently ceased operations and have certified that fuel has been permanently removed from the reactor. |

**Note**: NRC generic communications may be received in electronic format shortly after they are issued by subscribing to the NRC listserver as follows:

To subscribe send an e-mail to <listproc@nrc.gov >, no subject, and the following command in the message portion:

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