



The licensee stopped work, shielded and captured the particle, and initiated radioactive particle control zone coverage for the entire refueling floor. Additional actions undertaken at that time included formation of a root cause event review team. The team's work led to upgraded controls, surveying, more management oversight and more detailed planning and work procedures for handling high specific activity particles.

A search was then begun for additional hot particles on the refueling floor. Workers in particle control zones were surveyed for particles every 15 minutes, and more protective clothing (PC) was required for certain work activities. The 15-minute control was a default stay time, and not based on dose calculations for the high-activity particles known to be present.

During the cleanup activities, more than 30 radioactive particles were found on the refueling floor. Two high activity radioactive particles found on September 9 and December 6, 2000, had resulted in shallow-dose equivalent (SDE) exposures of 0.12 and 0.17 Sv (12 and 17 rem), which is below the annual SDE limit of 50 rem. The licensee discovered two more high-activity particles, a 0.78 Gbq (21 mCi) particle on November 28, and a 0.7 Gbq (19 mCi) particle on December 4, 2000; these particles did not result in significant exposure to personnel. No actual exposures in excess of any annual dose limits occurred during the cleanup activities.

During a scheduled NRC health physics, rad-waste transportation, baseline inspection during December 11-15, 2000 (Inspection Report Nos. 05000387/2000-009 and 05000388/2000-009, ADAMS Accession No. ML010250469), the NRC inspector identified significant weaknesses in the licensee's particle control program. The inspector noted that the licensee had failed to identify that conventional hand-held survey instruments using standard survey methods were underestimating the contact dose rates of the particles, thus underestimating the radiological hazards not just to the skin but in terms of whole body exposure.

The licensee's evaluation had failed to consider properly and account for the potential for substantial dose to personnel from the high-activity particles. Specifically, the 15-minute worker stay time was not adequate to prevent potential overexposures from the particles known to be present in and around the refueling floor. The stay time would have allowed both SDE and total effective dose equivalent (TEDE) annual exposure limits to be exceeded.

Four of the particles found ranged from 0.7 to 2.78 Gbq (19 to 75 mCi). Had the particles been directly on the workers' PCs, the TEDE annual limit of 0.05 Sv (5 rem) could have been exceeded in 25 seconds to 2 minutes, and the SDE limit exceeded in 6 to 21 seconds, depending on the activity of the individual particle.

In response to the NRC findings and a 0.17 Sv (17 rem) SDE exposure on December 6 from a particle on a worker's boot, licensee management stopped all high-risk work, initiated a comprehensive events evaluation, requested on-site assistance by an industry expert team, and implemented improved training and communication of lessons learned in this area.

## Discussion

During previous similar processing of irradiated components at Susquehanna in 1991, radioactive particles had been identified with external gamma dose rates greater than 100 rem/hr. However, the plant failed to incorporate fully this previous experience and industry-wide experience into the planning for the 2000 fuel pool clean out project. (NRC Information Notice No. 90-33, "Sources of Unexpected Occupational Radiation Exposures at Spent Fuel Storage Pools," also concerns highly radioactive particles.)

Prior to the NRC baseline inspection, after the initial event, the work controls that the licensee had implemented were not sufficient under the circumstances to evaluate and control the potential radiological challenges posed by these extremely high activity particles. A Notice of Violation (failure to conduct adequate evaluation and survey) associated with a White finding (using the Significance Determination Process) was issued. These actions were taken because of the substantial potential for exposure in excess of the annual limit for TEDE even though no worker dose limits were exceeded.

During the regulatory conference for this violation, the licensee stated that it needed to improve its hot particle surveying, identification, handling, and control. The improvements included more effective use of remote handling techniques, proactive staging of particle control zones, and aggressive treatment of potential sources of particles by using decontamination and filtration on systems that communicate with the spent fuel pool.

The licensee noted that in cases like this where a contractor was used for a challenging radiological evolution, plant management oversight was essential. That oversight must focus on, and have sufficient resources to implement and maintain a sense of an acceptable radiation culture and acceptable practices and standards for radiation work. According to the licensee, this can best be accomplished by direct ownership for significant, high-risk projects demonstrated by the visible presence and direct oversight of the work by utility managers.

Most importantly, this occurrence demonstrated a need to strengthen procedural controls to focus attention on the large potential doses from these challenging radiological work environments. The worker training program and job oversight must emphasize the most important lesson learned from the event—that radioactive particles can present not only shallow-dose risks but, at higher activity levels, whole body dose risks, which can be much more significant.

This information notice requires no 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 Office of Nuclear Reactor Regulation (NRR) project manager.

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