UNITED STATES
NUCLEAR REGULATORY COMMISSION
OFFICE OF NUCLEAR REACTOR REGULATION
OFFICE OF NUCLEAR MATERIAL SAFETY AND SAFEGUARDS
WASHINGTON, D.C. 20555

July 19, 2004

NRC INFORMATION NOTICE 2004-14: USE OF LESS THAN OPTIMAL BOUNDING ASSUMPTIONS IN CRITICALITY SAFETY ANALYSIS AT FUEL CYCLE FACILITIES

Addressees:

All licensees authorized to possess a critical mass of special nuclear material.

Purpose:

The U.S. Nuclear Regulatory Commission (NRC) is issuing this information notice (IN) to alert addressees to a safety concern arising from the use of less than optimal bounding assumptions in criticality safety analysis at fuel cycle facilities. It is expected 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 IN are not new NRC requirements; therefore, no specific action nor written response is required.

Description of Circumstances:

Under 10 CFR Parts 70 and 76, certain licensees processing, storing, or handling critical masses of fissile material are required to analyze all accident scenarios leading to criticality and provide reliable controls to assure that inadvertent criticality events are highly unlikely. Typical criticality analysis identifies credible accident sequences leading to criticality; identifies reasonable bounding assumptions related to the processes, equipment, or material analyzed; and establishes limits or boundaries of processes, equipment, or material within which bounding assumptions are applicable. Criticality may be deemed not credible when inherent features of the process, equipment, or material in a specific accident sequence leading to criticality can be shown to constrain the reactivity of fissile material within subcritical limits. The safety concern arises when accident scenarios leading to criticality are deemed not credible, based on bounding assumptions that are less than optimal for the system involved.

Recently, a licensee reported an event, to NRC, concerning operation of an incinerator outside of the approved safety basis. The licensee had performed a criticality safety evaluation of an incinerator approximately 8 years previously and concluded that criticality was not credible outside of the primary combustion chamber. Licensee nuclear criticality safety (NCS) analysis focused on accumulation of sufficient mass in the incinerator system to support criticality.

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Based on mass limits on the input waste stream, licensee NCS engineers determined that most mass resulting from incineration would accumulate in the primary combustion chamber and that ash resulting from incineration would never exceed a concentration of 21.6 weight percent uranium (wt% U) which is always subcritical in infinite media at the optimal moderator ratio. Based on this conclusion, criticality safety limits and controls were developed and implemented only for the primary combustion chamber, which was a small fraction of the incinerator system.

Licensee NCS engineers believed that very limited amounts of ash would carry over from the incinerator primary combustion chamber to the remainder of the incinerator system and that mass controls on the primary combustion chamber would limit uranium concentration in the ash to less than 21.6 wt% throughout the incinerator system. This led the licensee's NCS engineers to conclude that criticality outside the primary combustion chamber was not credible.

On March 5, 2004, the licensee reported an event concerning the accumulation of significant quantities of ash outside the primary combustion chamber at concentrations in excess of 21.6 wt% U. The licensee's investigation revealed that ash deposits at various locations in the incinerator routinely exceeded the 21.6 wt% uranium concentration assumed to be bounding for ash and that the mass of ash deposited also exceeded expectations.

Discussion:

In the described event, the chosen uranium concentration was arbitrary and did not bound the subject fissile system. 21.6 wt% U is not a natural limit on U concentration in incinerator ash and is less than optimal because higher uranium concentrations produce a more reactive fissile system. The value results from an infinite media calculation where optimum moderation conditions are established with ash replaced by a uranium dioxide and water mixture. The limiting concentration is related to the critical point, in this case k_{eff} = 0.98.[1] To complete analysis of the incinerator, the licensee looked at data from selected parts of the incinerator system and concluded that 21.6 wt% U far exceeded uranium concentrations typically expected in the system. However, U concentration frequently exceeded 21.6 wt% in the primary and secondary combustion chambers and flue. The licensee failure to recognize that the actual U content of the ash was related, in part, to weak documentation of bounding assumptions and poor definition of incinerator system boundaries to which the bounding assumptions applied. The accumulation of material outside the primary combustion chamber at the U concentrations seen, along with the availability of water in the incinerator off-gas quench system, results in the conclusion that criticality was actually credible in the incinerator secondary combustion chamber.

Less than optimal bounding assumptions for criticality safety are most often seen in ventilation and off-gas systems, waste-processing systems, and incinerators. Licensees should consider actions, as appropriate, to mitigate this vulnerability. These actions could include reviewing all accident sequences where less than optimal bounding assumptions were used to establish NCS controls or determine that criticality is not credible. Actions could also include verifying

[1] k_{eff} is the effective neutron multiplication factor for the system under consideration. The licensee had defined the critical point in its license as k_{eff} =0.98.

that bounding assumptions are actually bounding, for example, by reviewing available material composition data for evidence that attributes such as isotope concentration are actually within expected values.

This IN requires no specific action nor written response. If you have any questions about the information in this notice, please contact the technical contact listed below.

/RA/

William D. Beckner, Chief
Reactor Operations Branch
Division of Inspection Program Management
Office of Nuclear Reactor Regulation

/RA/

Robert C. Pierson, Director
Division of Fuel Cycle Safety
and Safeguards
Office of Nuclear Material Safety
and Safeguards

Technical Contact: Dennis Morey, NMSS
301-415-6107
E-mail: dcm@nrc.gov

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Information Notice No.	Subject	Date of Issuance	Issued to
2004-13	Registration, Use, and Quality Assurance Requirements for NRC-Certified Transportation Packages	06/30/2004	All materials and decommissioning reactor licensees.
2004-03	Radiation Exposures to Members of the Public in Excess of Regulatory Limits Caused by Failures to Perform Appropriate Radiation Surveys During Well-logging Operations	02/24/2004	All well-logging licensees.
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.
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2004-12	Spent Fuel Rod Accountability	06/25/2004	All holders of operating licenses for nuclear power reactors, research and test reactors, decommissioned sites storing spent fuel in a pool, and wet spent fuel storage sites.
2004-11	Cracking in Pressurizer Safety and Relief Nozzles and in Surge Line Nozzle	05/06/2004	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.
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