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Editors' Note

It has long been known that the fission products that are created and accumulate in nuclear fuel during its irradiation in a reactor are a hazard, and a great deal of attention has focused on understanding how this radioactivity could be released during a reactor accident and what might be the consequences. This issue of the journal features two articles exploring the progression of possible events that might lead to the accidental release of a large fraction of the radionuclides in spent fuel once the spent fuel has been taken out of the reactor, and use advanced computational tools to model the atmospheric dispersion and deposition from such accidents. They show that there are accident pathways with potentially catastrophic consequences when spent fuel is dense-packed for storage in a water-filled pool to cool it down after discharge from a reactor and also after the spent fuel has been reprocessed and the separated fission products are stored in tanks as high-level liquid radioactive waste.

"Reducing the Danger from Fires in Spent Fuel Pools" by Frank N. von Hippel and Michael Schoeppner examines the consequences of a loss of water from a nuclear power plant's spent-fuel pool, where the spent fuel heats up and catches fire and releases large quantities of the cesium-137 in the fuel into the atmosphere. This was an issue explored in the journal in 2003 in "Reducing the Hazards from Stored Spent Power-Reactor Fuel in the United States" by Robert Alvarez, Jan Beyea, Klaus Janberg, Jungmin Kang, Ed Lyman, Allison Macfarlane, Gordon Thompson, and Frank N. von Hippel, and the responses from Sandia National Laboratory and from the United States Nuclear Regulatory Commission. This issue has grown in importance following the nuclear disaster in Japan after the earthquake and tsunami of 11 March 2011, which included a near-catastrophic failure of the cooling system and structural integrity of the spent fuel pool at reactor number 4 at Fukushima. This near-disaster led to studies of spent fuel pool safety in the United States, including by the Nuclear Regulatory Commission and the National Academy of Sciences

The article by von Hippel and Schoeppner traces the events in pool number 4 at Fukushima and uses the HYSPLIT code developed by the Air Research Laboratory of the U.S. National Oceanic and Atmospheric Administration for atmospheric dispersion and deposition calculations to show that had the cesium-137 been released, and had the wind been blowing toward Tokyo (which it was on 19 March 2011, eight days after the earthquake and tsunami), 35 million people out to a distance of 225 km might have required relocation. The article looks also at the case of a hypothetical release from the spent fuel pool at the Peach Bottom reactor in Pennsylvania—the case studied by the Nuclear Regulatory Commission using the MELCOR Accident Consequence Code System (MACCS). von Hippel and Schoeppner find the size of areas that would be too contaminated to allow people to remain there and the populations requiring relocation to be much larger than were estimated by the Nuclear Regulatory Commission. The article also challenges the cost-benefit calculations and the rules for assessing health risks to individuals and populations used by the Commission as the basis for allowing dense-packing of spent fuel pools to continue rather than requiring a transition to low-density storage so as to reduce the risks and consequences of an accident or a terrorist attack at a spent fuel pool.

The second article in this issue, "Nuclear High-level Waste Tank Explosions: Potential Causes and Impacts of a Hypothetical Accident at India's Kalpakkam Reprocessing Plant," by M. V. Ramana, A. H. Nayyar, and Michael Schoeppner, deals with hazards associated with tanks holding large inventories of radioactive materials in the form of liquid high level waste from reprocessing of spent fuel. It discusses three kinds of chemical explosions that have occurred at reprocessing and associated facilities—red oil explosion, salt explosion, and hydrogen explosion—and their potential for occurrence at a high level waste tank. It outlines a hypothetical scenario involving a chemical explosion at a tank at India's Kalpakkam Reprocessing Plant, located 65 km south of Chennai, a major city. The scenario assumes 10% of the radioactive contents of one of the tanks is released in the form of small aerosol particles and uses the HYSPLIT code to follow this release until it is mostly deposited (about 140 hours) and assesses the ground contamination, interdicted area, and finds the collective radiation dose to the population just from ground contamination by cesium-137 could lead to possibly several tens of thousands of cancer deaths.

Finally, this issue carries a research note, "BN-800: Spent Fuel Dose Rates and the Plutonium Management and Disposition Agreement" by Friederike Frieß and Moritz Kütt. Building on an earlier article they had in the journal with Matthias Englert ("Plutonium Disposition in the BN-800 Fast Reactor: An Assessment of Plutonium Isotopics and Breeding," 2014) the new work offers a check on a key requirement of the Plutonium Management and Disposition Agreement (PMDA) between Russia and the United States. This agreement committed each state to dispose of 34 tons of excess weapon plutonium, and in the case of Russia allowed this disposition to include using the plutonium as fuel in the BN-800 fast reactor, which began operation at the end of 2015.

The article uses computer modeling to check whether BN-800 spent fuel would meet the requirement that the "radiation level from each spent plutonium fuel assembly is such that it will become no less than 1 sv/h, 1 m from the accessible surface at the centerline of the assembly 30 years after irradiation has been completed." It finds that the fuel in the axial and radial breeding blankets would not meet the PMDA threshold, and neither does fuel in the core if withdrawn after one third of the full design irradiation period. The authors recommend establishing arrangements to monitor reactor power and irradiation times that would have to be agreed by the two states with the International Atomic Energy Agency.