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TELLURIUM PRECURSOR EFFECTS ON IODINE TRANSPORT IN A BWR ACCIDENT

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This study describes the increase in iodine activity released to the atmosphere during a severe accident due to the radioactive decay of tellurium precursors. It is particularly significant since several recent studies have totally ignored this phenomenon.[1,2] The work involves the analysis of a loss of decay heat removal (LDHR) accident at Browns Ferry Unit 1,[3,4] as part of a general effort conducted by the Severe Accident Sequence Analysis Program at ORNL with full cooperation from the Tennessee Valley Authority. The program is sponsored by the Containment Systems Research Branch of the Office of Nuclear Regulatory Research, USNRC, in order to examine the possible effects of potential nuclear power plant severe accidents.

The LDHR sequence is a long BWR accident, which involves incomplete removal of decay heat from the pressure suppression pool after reactor scram. Reactor vessel depressurization causes steadily increasing temperature and pressure in the drywell, which ruptures due to over-pressure, releasing hot steam into the reactor building. It is postulated that the resulting harsh conditions interrupt the supply of cooling water to the core, leading to core uncovery, cladding failure (39 hrs. after shutdown), fuel melting, core slump into the vessel bottom head, and bottom head failure (43 hrs.). The core debris falls onto the concrete drywell floor, where subsequent interaction releases most of the remaining fission products from the fuel. All major events and activity releases occur within 50 hrs. after shutdown.

A code has been developed at ORNL to estimate the behavior of fission products in BWR accidents such as the LDHR sequence described above. Models are included to describe the release of nuclides from fuel[5] and their subsequent transport, decay, and chemical interactions.[4] Specific models are used to calculate the distribution of chemical species, dissolution in water, and deposition or condensation onto fixed surfaces and aerosols. An efficient algorithm allows computation of the decay for each nuclide in each control volume. Details of the LDHR sequence and fission product transport analysis can be found elsewhere.[3,4]

Recently, LDHR sequence calculations by two different procedures have underscored the importance of radioactive decay in fission product transport. In method I, radioactive decay of each nuclide is computed in each control volume at each time step by the code mentioned above. The resulting atmospheric inventories at the end of the sequence are shown in the second column of Table 1. Method II uses the same code, but decay during the LDHR sequence is ignored, so that total nuclide inventories remain constant. Average activity per unit mass of each element (PBq/gmol) is determined using nuclide mass inventories obtained from ORIGEN[6] results at 50 hr. Multiplying these by the total elemental masses (gmol) released to the atmosphere yields the elemental atmospheric activities shown in column 3 of Table 1. As can be seen in the table, the activities of Kr, Xe, and Cs do not vary appreciably between the two methods; however, there is a significant difference in the iodine inventories, both in the gas phase and on aerosols.

To understand the discrepancy, consider the contributions of ^{132}I to the total iodine release calculated by method I, as illustrated in Table 2. Here it is seen that the iodine activity in the atmosphere is due disproportionately to ^{132}I. Unlike the longer-lived isotopes, most ^{132}I

(half-life of 2.30 hr.) existing early in the accident will decay before the significant atmospheric releases which follow reactor vessel failure. However, the supply is replenished by the decay of ^{132}Te, which is released in large quantities from the drywell rubble. Thus, the atmospheric release of ^{132}I depends heavily on the behavior of tellurium in the drywell and reactor building.

As seen above, the physical and chemical behavior of precursors can be important in fission product transport calculations. The effects may be much more important in shorter accidents, where many short-lived isotopes would be present initially. Precursor effects may also be substantial in small consequence accidents, where tight transport resistances could vary considerably due to precursor behavior. Thus, a complete fission product transport analysis must model the behavior and decay of precursors as well as the behavior of daughter nuclides.

References

1. J. A. Gieseke et al., "Radionuclide Release Under Specific LWR Accident Conditions," BMI-2104, Volume II (1984).

2. "Peach Bottom Atomic Power Station," IDCOR Task 23.1, Integrated Containment Analysis (1984).

3. S. A. Hodge et al., "Loss of DHR Sequences at Browns Ferry Unit One - Accident Sequence Analysis," NUREG/CR-2973 (ORNL/TM-8532), Oak Ridge National Laboratory (1983).

4. R. P. Wichner et al., "Noble Gas, Iodine, and Cesium Transport in a Postulated Loss of Decay Heat Removal Accident at Browns Ferry," NUREG/CR-3617 (ORNL/TM-9028), Oak Ridge National Laboratory (1984).

5. Fuel releases derived from a modification of "Technical Bases for Estimating Fission Product Behavior During LWR Accidents," Chapter 5, NUREG-0772 (1981).

6. A. G. Croff, "ORIGEN2 - A Revised and Updated Version of the Oak Ridge Generation and Depletion Code," ORNL-5621, Oak Ridge National Laboratory (1980).

Table 1. Comparison of Fission Product Atmosphere Inventories Calculated by Two Different Methods

Element	Atmospheric Activity (PBq) at 50 hrs. Method I	Method II
Kr	23.90	23.62
Xe	4629	4480
I(gas)	12.64	2.89
I(aerosol)	0.140	3.89×10^{-5}
Cs(gas)	1.45×10^{-3}	1.61×10^{-3}
Cs(aerosol)	2.26×10^{-5}	2.39×10^{-5}

Table 2. Contributions of ^{132}I to Iodine Inventories

Time (hr)	Location	Fractional Contribution of ^{132}I (%) Activity (% PBq)	Mass (% gmol)
30 [a]	Fuel	38.9	0.039
43 [b]	Atmosphere gas	35.1	0.028
50 [c]	Atmosphere gas	86.1	0.29
	Atmosphere aerosol	88.6	0.36
	Total	42.8	0.032

[a] As determined by ORIGEN code before fuel failure.

[b] Immediately prior to pressure vessel failure.

[c] End of accident sequence.