N170. The Effect Of Chemical Additives On N-16 Carryover Under Simulated BWR Conditions

It is well known that N-16 activity is the dominant radionuclide in BWR steam plant components and condenser ejector effluent. Even so, most is retained in the liquid phase, presumably as NO_3 (and some NH_3). Hydrogen addition results in a large increase in N-16 carryover, undoubtedly as NH_3. The need for a better understanding of N-16 chemistry motivated a series of tests in a specially constructed BWR test loop in the MIT reactor, with the ultimate goal to find a way to enhance retention by the liquid phase, if such exists. To this purpose, a wide variety of chemical additives were injected into the subject BWR loop, and their effect on the N-16 concentration in effluent water and steam measured.

The loop was operated in a once-through mode, exposing feedwater to representative BWR incore neutron plus gamma doses. Exit steam qualities ranged from 0-15%, and while normal BWR water chemistry was the principal focus, Hydrogen Water Chemistry (HWC) was also simulated. N-16 activity was measured in both the steam and water phases leaving the separator plenum downstream of the in-core section.

Nitrogen-16 (half-life = 7.13 sec., emitting 6.129 MeV gammas) was detected using a system of two NaI scintillation crystals, flow plena for the water and steam effluents, and a Series 20 Canberra MCA. The detectors were placed in separate lead shield blocks to eliminate background and were positioned to count immediately after the effluent exits the core tank to minimize decay. The N-16 photopeaks, and their single and double escape peaks, were all evident in the spectra and were counted using lower and upper energy cutoffs of 4.6 and 8.1 MeV, respectively.

Table 1 shows the effect of each additive at about 10 moles/liter on the relative ratio of steam-to-liquid N-16 detector count rates. As can be seen, most additives increased N-16 carryover: reducing agents (e.g., H_2 and NH_4OH) had most dramatic effects. Another viewpoint is to associate increase with hydrogenous chemicals (other than OH). Oxidizing agents had little effect, while HCl caused a moderate decrease. Although further interpretation is in order, these results are consistent with a model in which N-16 is present as $^{16}NH_3$. While most of the subject additives may not normally be encountered in BWR operation, two are of practical interest. Trimethylamine and benzene sulfonic acid are degradation products of the ion exchange resins used to purify BWR feedwater. The results confirm plant operator observations that their inadvertent exposure to in-core irradiation is accompanied by an increase in N-16 carryover.

Table 1

SUMMARY OF N-16 CARRYOVER CHEMISTRY STUDIES

ADDITIVES	VAPOR PHASE ENHANCEMENT
H_2,C_2H_5OH,NH_4OH	4.5,5.0,5.7 $C_6H_5SO_3Na$,NH_3OHCl,CH_4,CO
3.7,3.8,4.1,4.2 KNO_2,NO,$N(CH_3)_3HCl$	2.5,2.7,2.7 H_2O_2,KOH,CO_2,N_2O,N_2
1.0+/-0.05	
HCl	0.8

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