N157. Standard Versus Hydrazine Water Chemistry In VVER-440

The radiation fields in VVER primary systems during shutdown periods are essentially generated by activated corrosion products. The origin of these radiation fields is linked firmly to the chemical composition of the materials used to construct the cooling circuits and to primary circuit water chemistry. Only the water chemistry can be changed to influence the level of dose rate build-up. Although the design of all VVER-440s is basically the same, dose rate build-up and occupational radiation exposure (ORE) vary considerably from plant to plant. This can perhaps be explained by differences in the extent to which remote technology is used, different styles of job management, different cobalt impurities in in-core and out-of-core materials, and the water chemistry regime used. The first two of these factors influence ORE itself but have no effect on dose rate build-up; but optimizing primary coolant chemistry and decreasing cobalt impurities directly affect out-of-core surface activities.

Water Chemistry Regimes

Data for water chemistry, surface activities, coolant activities, dose rates, and occupational radiation exposures were collected and evaluated for 28 international VVER-440 plants. At most of these plants, standard primary circuit water chemistry is used, but hydrazine water chemistry is used at Kola 3 and 4 and at Rovno 1 & 2 in the USSR. The Co content in Soviet stainless steel has an average value of 0.075%. The standard water chemistry is similar to that used for western PWRs and the potassium boron mode is the same for all VVER-440s. The coolant pH (300 degrees C) reached under this mode is approximately 7.0.

Buildup Of Surface Activity

The theoretical ratios of surface activities (SA) for Inconel 600 (nickel content 75%) and stainless steel (nickel content 10%) used for steam generator tubes in Western PWRs and VVERs are: for Co-58 - SA(PWR)/SA(VVER) = 7.5; for Co-60, cobalt content 0.05% - SA(PWR)/SA(VVER) = 1.4; for Co-60, cobalt content 0.02% - SA(PWR)/SA(VVER) = 1.9.
The calculation of these values assumed the following conditions:

- Equal transport of cobalt and nickel in primary circuits.
- Average ratios of epithermal to thermal neutrons of 7 for VVER-440s, and 5 for PWRs
- Roughly the same neutron densities, corrosion rates, and total steam generator tube areas.

The measurements of actual surface activities show that surface activity is considerably lower at VVER-440s than at Western PWRs which use stellite and high nickel content alloys. Units using hydrazine water chemistry achieve lower levels of Co-58 on steam generator surfaces. For the other isotopes, the values corresponding to standard and hydrazine water chemistry are comparable.
References: 1) V.I. Paschevitch et al., "Hydrazine Regime for the Primary Circuit of VVER-440 and VVER 1000s", IAEA meeting, Vienna, May 6-9, 1991. 2) V.I. Paschevitz, "USSR Experience in the Fields of Decontamination and Water Chemistry Regimes in the Operation of VVERs", IAEA meeting, Vienna, May 6-9, 1991.

Taken From: "Standard versus Hydrazine Water Chemistry in VVER-440s: a Score Draw," by Jana Burclova, Nuclear Engineering International, pp. 34-37, November 1991.