Ammonia Role in the Formation of Radiation Fields in VVER

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The ammonia influence on magnetite and nickel ferrite solubilities at 350 C and the different relations of boric acid and alkaline cation sums are considered. The influence of ammonia concentration on dose rate from steam generator headers in VVER-440 is investigated on the basis of water chemistry data and dose rate data from equipment in NPPs, where ammonium and hydrazine water chemistry regimes are realized. The connection between radiolytical hydrogen concentration and dose rate is shown. It is argued by thermodynamic calculations that ammonium complex formation under transients has an essential influence on mass transfer and dose rate. Ammonia in the coolant influences dose rate by two mechanisms:

- complex formation with oxides and hydroxides of (Fe, Co, Ni) corrosion products;
- variations of radiolytical hydrogen concentrations.

Thermodynamic calculations of concentrations of Fe(II) and Ni(II) ammonium complexes, depending on temperature, were carried out. The literature data on stability constants and enthalpy of formation were employed. Calculations show that only one-atomic complexes can create a significant concentration in the coolant, moreover Ni(II) complex concentration is sufficiently higher than Fe one. Concentration of first Ni(II) complex is compared with solubility of Ni(II) ferrite, therefore it may be supposed, that Ni(II) complexes with ammonia play an essential role in Ni-contained corrosion products transfer under shutdown. Capability of Fe(II) to form ammonium complexes decreases with temperature rise. Under low temperatures (shutdown) concentration of Fe(II) ammonium complexes is compared with concentrations of Fe-contained corrosion products in the circuit and can play in important role in mass transfer. Concentration of ammonium complexes is decreased with temperature rise. It is well known that the process of precipitation is controlled by Fe(II) hydroxide concentration. Under 300 C, pH=6-7 and hydrogen concentration 40 ppm, correlation of Fe(II) hydroxide concentration and total concentration of soluble Fe(II) is only 0,001. Correlation of concentrations of Ni(II) ammonium complexes and total concentration of soluble Ni(II) is sufficiently higher in the whole range of temperatures (up to 300 C), so ammonium complexes of Ni(II) play an important role in the mass transfer of soluble radionuclide corrosion products during their entire lifetime. Ammonium complexes of Fe can give an essential contribution to mass transfer only under temperatures below 150 C, i.e. under shutdown.