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EXPERIENCE FROM SEVERE FUEL FAILURES IN RINGHALS: RADIOLOGICAL EFFECTS AND SHUT-DOWN CRITERIA

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Objectives: To avoid long term radiological problems from severe fuel failures and develop shutdown criteria.

Ringhals 1 is a 835 MW BWR commissioned in 1976. In the years 1992-94 it experienced fuel failures which led to an extensive dissolution of fuel (some 300 grams). The uranium and transuranium nuclides dissolved were partially transferred to the ion exchange resins in the reactor water clean-up circuit, where they committed part of the inventory of the final repository for medium level waste. Some 25% of the dissolved fuel was deposited as tramp uranium on the surfaces of the core. This part of the uranium produces a range of short-lived noble gas nuclides, which follows the steam to the turbine system. The tramp uranium is strongly bound to the fuel crud deposits; it decreases 30-40% per year. Half of the removal stems from the discharge of fuel and the other half from dissolution. The effective half-life on the core will be about 1.5 years. Hence, the radiological effects from an event with fuel dissolution will last for 5-10 years.

Comments: The radiological impact from the tramp uranium comprises the following areas:
(1) In a first generation BWR with a short delay of the ejector off-gas the airborne releases of the noble gases contributes a fairly high dose rate to the critical group, 40-50 μSv/year.
(2) In the turbine system, the short lived noble gas nuclides decay into non-volatile products, such as Ba-140 and La-140, which contributes to dose-rate and airborne contamination. The collective dose for turbine maintenance increased from 10 person-mSv in 1991, when there were no fuel failures to 100 person-mSv in 1993 when there were fuel failures as well as tramp uranium.
(3) In the reactor system the surface contamination from alpha emitters was about 1 MBq/m^2, mainly from short lived Cm-242.
(4) The presence of airborne alpha activity introduced monitoring problems, since the concentrations of radon daughters (as gross alpha) was of the same order as the DAC value for transuranics.
(5) The presence of tramp uranium also seems to increase the release of Co-60 from the fuel crud. This in turn, causes increased dose rates on the piping and components of the reactor systems.

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Remarks: When a fuel failure leads to a dissolution of uranium, it is important to determine the amount of dissolved fuel by radiochemical monitoring. In Ringhals diffusion analysis of noble gases and iodine was used to distinguish between the release from the leaks and from tramp uranium. To prevent excessive dissolution and long term problems, it is also important to have criteria to shutdown the reactor and replace the failed fuel before too much fuel has been dissolved. These criteria have to be developed for each reactor, taking into account gaseous releases, radiological impact on the plant and waste production. In Ringhals 1 the releases of noble gases to the environment will be the strongest limitation. The contents of transuranics in the medium level waste allows a higher level of dissolved fuel. The increased doses to personnel and the demand for extra protective measures put the approximately the same limits on the dissolved uranium as the release limitations do. In a PWR plant the dissolution rate of uranium seems to be lower than in a BWR. Releases to the environment and the dose contributions to personnel from dissolved uranium are also lower in a PWR. Experience from the PWRs Ringhals 2-4 shows this.

References: Aronsson, P. O., O. Erixon, G. Granath and T. Svedberg, "Experience with Fuel Failures in Ringhals Radiological Effects and Shutdown Criteria," Proceedings, EPRI Radiation Field Control and Chemical Decontamination Seminar, Tampa, Florida, November 1995, available from EPRI Distribution Center, P.O. Box 23205, Pleasant Hill, CA 94523, Phone: (501)934-4212.

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