N179. Radiation-Field Control Manual - 1991 Revision

This updated revision of the *Radiation-Field Control Manual* issued in 1986 by the Electric Power Research Institute (EPRI) describes recent techniques developed for reduction of out-of-core radiation fields in Light Water Reactors (LWRs). Recent developments aimed at reducing cobalt sources, preconditioning surfaces, controlling water chemistry, and decontamination are reviewed. EPRI guidelines on cobalt source reduction and Pressurized Water Reactor (PWR) primary coolant chemistry are mentioned. Currently available methods for controlling plant radiation fields are described.

Cobalt Source Reduction

The main source of cobalt in LWRs is cobalt-containing hardfacing alloys. However, low level impurities in structural alloys are also contributors. EPRI has developed guidelines for cobalt reduction in plants which cover three types of valves:

- Control valves should have the hardfacing removed and replaced with other base material.
- Check valves with a seat should be treated in the same manner as control valves. Check valves with a pivot bushing should be replaced with nickel-based alloys.
- Gate, globe, and other valves under light loads should be replaced with nickel-based alloys. Stellite may be retained in those valves under heavy loads or they may be replaced with equivalent cobalt-free iron-based hardfacing alloys if a suitable replacement exists.

Three of the most promising cobalt-free iron-based hardfacing alloys are being tested by Atomic Energy of Canada, Ltd. (AECL). These alloys are NOREM, EB 5183, and Everit 50. The tests are indicating that these alloys are as good as Stellite and that NOREM-04 in particular appears to be a suitable replacement. Results of tests by various organizations that have evaluated NOREM and Stellite under identical conditions are available from EPRI.

Whenever possible, it is important to replace components with low cobalt alternatives. Zircaloy fuel spacer grids should be used in reload fuel. When ordering other replacement parts such as Inconel tubing, materials with low cobalt impurity levels should be requested.

Preconditioning Of Out-Of-Core Surfaces

Preconditioning has proven to be useful in reducing dose in both PWRs and Boiling Water Reactors (BWRs). The steam generator channel heads in PWRs need preconditioning as well as the primary recirculation piping in BWRs. The three major preconditioning processes that may be used are mechanical polishing, electropolishing, and preoxidation. These are most effective when used together.

- Mechanical polishing is used to remove the oxide layer from the pipe. Sandblasting is a rather extreme form of this and has proven ineffective.
- Electropolishing is now being widely adopted and seems effective. Concerns over metallurgical damage have not proven to be justified.
- Preoxidation involves prefilming the surfaces to give a protective oxide layer before exposure to reactor water. The combination of electropolishing and preoxidation is being used at many plants in the United States and should lower dose significantly.

Control Of Corrosion Product Transport And Activation In Reactor Systems

Regulating reactor water chemistry can be a major factor in reducing dose rate. Methods to do so differ depending on reactor type.

PWR Coolant Control - The CRUDSIM model has predicted that a pH of 7.4 (300°C) will result in the lowest possible dose rate. However, there are concerns about possible corrosion of Inconel 600 alloy. Early unconfirmed tests have shown no ill effects. Inconel 690 alloy is more corrosion-resistant and can be used as an alternative.
PWR shutdown has been a focus for developing dose reduction procedures. Early shutdown boration at Beaver Valley 1 has reduced radiation fields by 20%. The addition of hydrogen peroxide during shutdown acts to release the cobalt-58 and cobalt-60 quickly in order to reduce exposure from these sources.

BWR Coolant Control - Hydrogen Water Chemistry (HWC) has been used to combat intergranular stress corrosion cracking. It increases fields due to nitrogen-16 as well as shutdown fields, but overall can reduce dose since it requires less maintenance and inspection. Oxygen injection is effective when concentration is less than 20 ppb. Zinc injection has proven very useful for reducing dose as it helps control fields due to cobalt.
BWR shutdown has also been investigated. A "soft" shutdown has been tested in Germany with impressive results. It lowered collective exposures to 50-100 man-rem during refueling and maintenance. These shutdown practices involved:

- Temperature reduction gradients of 15°C/hr rather than 30°C/hr.
- Keeping reactor power at 0% prior to pressure and temperature reduction.
- Reducing steam generation rate by holding pressure at 45 bar for two hours.

Chemical Decontamination

Chemical decontamination is widely used to reduce dose at plants. This technology has improved recently and there are currently four viable decontamination processes. These are: LOMI, CAN-DEREM, CITROX, and CORD.

LOMI - This process is used extensively at plants in the United States. The process is vanadous picolinate/formate in which the vanadous ions reduce the oxidation state of the iron in the oxide so it can be dissolved in the picolinic acid. It has generally had good decontamination factors in BWRs with 1 or 2 applications.
New improvements to the process have been developed. The vanadous supplier was able to reduce the formic acid levels which cuts the volume of ion-exchange resins by 1/2. Reduction of the picolinic acid to vanadous formate ratio to about 3:1 has been shown to reduce the ion-exchange waste volume and lower costs. The addition of NaOH near the end of the process makes the removal of the acids easier.

CAN-DEREM - This process was developed by Atomic Energy of Canada, Ltd. (AECL) and was derived from their CAN-DECON process. CAN-DECON uses citric acid, oxalic acid, and EDTA. CAN-DEREM eliminates the oxalic acid so as not to corrode 304 stainless steel. Decontamination factors ranging from 5 to 10 have been achieved with CAN-DECON. CAN-DEREM has shown similar results for both BWRs and PWRs but takes more time.

CITROX - This process is a dilute regenerative process developed by Pacific Nuclear Services. It is based on the AP-CITROX process developed by the Atomic Energy Commission in the 1960s. The CITROX solvent is a blend of dilute organic acids. It has been used in about 20% of all United States decontaminations.

CORD - This is a German process which has been used successfully in both BWRs and PWRs. It involves an acidic and reductive dissolution and generally is applied with a preoxidation step. For 3 cycles, decontamination factors between 20 and 35 have been demonstrated in the primary loop and steam generator for the BR-3 PWR.

Improvements in ion-exchange resins have helped all of these processes. In particular, Ionac A-365 has 2.5 times the capacity of previous ion resin beds.

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