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Processes and Practices Related to Occupational Dose

ID: 8

COBALT QA PROCEDURES ON INCONEL FUEL AND GRIDS (PWRs) AND ON FUEL, PINS, AND CONTROL BLADES (BWRs)

Keywords: COBALT QA PROCEDURES; FUEL; GRIDS; PINS; CONTROL BLADES; INCONEL; COBALT; CONTAMINATION PREVENTION; MATERIALS OF CONSTRUCTION

Description:

An effective cobalt reduction program beings with the removal of the source. Although ALARA-enhanced measures such as chemical decontamination, sub-micron filtering devices, and zinc passivation techniques are effective exposure control techniques, source removal is obviously the most effective crud elimination technique.

Many PWRs use brazed Inconel fuel grids. Nickel plating of the grids is one of the fabrication steps involved in the brazing process. In some cases, the nickel has had high levels of cobalt. For example, for Borssele fuel it was determined that nickel with up to 3.4% cobalt had been used. High plant radiation levels were traced to the cobalt coming from the grid plating. Once the problem was identified and fuel grids with the highest levels of cobalt were replaced with low-cobalt fuel grids, the radiation levels started decreasing. Current Borssele fuel assemblies use nickel with less than 50 ppm cobalt.

Based on the above experience, it is clear that any utility using fuel with brazed Inconel grids should ensure that low-cobalt nickel is used in any brazing operations involved in grid fabrication. In addition, low cobalt levels should be specified for the Inconcel (e.g., 0.02% maximum).

Similarly, the industry has been moving towards use of Zircaloy fuel assembly grids in PWR designs instead of grids containing Inconel parts and nickel braze material. The use of low-cobalt Inconel X-750 springs in BWR fuel assemblies has become standard.

BWR control rods include rollers on each blade to position the blade between adjacent fuel assemblies. The rollers are held in place by pins. The original pins and rollers used for the control rods were made of high-cobalt alloys. Since the pins and rollers are continuously exposed to the core neutron flux, a significant amount of the cobalt is transmuted to cobalt-60. Accordingly, wear and corrosion of these pins and rollers was a very significnat source of cobalt-60. In an EPRI-sponsored research program, low-cobalt pins and rollers were developed and qualified. Use of low-cobalt materials is now the standard in replacement control blades. Because control rods require periodic replacement, the high-cobalt alloy pins and rollers are gradually being eliminated. Sufficient information is not available to conclude whether it is cost effective for utilities to prematurely replace control blades that have the high-cobalt pins and rollers.

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References and Selected Abstracts:

1. H. Ocken, "Cobalt Reduction Guidelines," EPRI Special Report NP-6737, March 1990. (Available from Research Reports Center, Box 50490, Palo Alto, CA 94303.)

2. C.J. Wood, "Manual of Recent Techniques for LWR Radiation Field Control," EPRI Special Report NP-4505-SR, March 1986. (Available from Research Reports Center, Box 50490, Palo Alto, CA 94303.)

ABSTRACT: This manual identifies the following techniques as highly cost-effective in reducing occupational raditaion exposure.

o Before power raising - For BWRs, replace cobalt alloys in control blades and control oxygen during hot functional tests; for PWRs electropolish channel heads and control chemistry in hot functional testing.
o During operation - For BWRs, minimize feedwater iron input, improve reactor water quality, and use zinc injection; for PWRs, control pH and add peroxide at shutdowns.

o Refueling - Use low-cobalt materials in replacement fuel and cobalt-free pins and rollers in BWR control blades; use Zircaloy grids in replacement fuel for both types of reactors.

o Maintenance - For BWRs and PWRs, replace wearing valves with cobalt-free alternatives and improve valve maintenance procedures to remove debris.
o Special maintenance and repairs - For BWRs, decontaminate, electropolish replacement piping, and air-condition or water prefilm replacement piping; for PWRs, decontaminate, electropolish channel heads, and use low-cobalt Inconel for replacement steam generator tubing.

o Plant life extension - For BWRs and PWRs, decontaminate complete primary system.

3. P. Aldred, "BWR Control-Rod Cobalt-Alloy Replacement," EPRI Final Report, March 1982.

ABSTRACT: Cobalt base pin and roller alloys in BWR Control Rods are a source for the Co-60 isotope which contributes to radiation buildup in the BWR core, the recirculation piping system and the spent fuel pool. It thereby influences personnel radiation exposure during BWR plant maintenance. The program objectives were (a) to identify non-cobalt alloys which could potentially replace the cobalt alloys, (b) evaluate the alloys by testing to qualify them for in-reactor surveillance testing, and (c) to initiate reactor tests at 2 BWRs.

Wear resistance, an important requirement for pins and rollers, was measured in a simulated BWR environment (excluding irradiation). Prototypic wear tests were emphasized and a prototype control rod drive test facility was used to evaluate several pin and roller alloy combinations during prototype control road operation. These tests, simulating a 5-year duty cycle in a BWR, were supplemented with laboratory wear tests. Two non-cobalt pin and roller alloy combinations were identified which had equivalent or better wear resistance than the conventional cobalt alloys. Other laboratory tests on these non-cobalt alloys showed them to have superior impact strength and similar corrosion resistance to the conventional cobalt alloys.

Reactor tests were initiated at a control cell core BWR and at a conventional core BWR. Four control rods containing non-cobalt alloy pins and rollers were installed in each BWR.

4. I.R. Brookes and M.V. Polley, "Reduction of Co-60 and Co-58 by Employment of Zircaloy Fuel Grids in PWR," Proceedings of the INternational Workshop on New Developments in Occupational Dose

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Control and ALARA Implementation at Nuclear Power Plants and Similar Facilities, held at Brookhaven National Laboratory, Upton, New York, September 18-21, 1989. NRC NUREG/CP-0110, p. 185.

ABSTRACT: We have investigated the proposition that replacement of Inconel 718 fuel grids with Zircaloy will lead to substantially lower reactor coolant circuit dose rates and to reduced liquid radwate output. The method has been to calculate the activation to Co-60 and Co-58 in the nickel-plated Inconel 718 grid material (taking into account all significant activation and burnout reactors) and to calculate the release to circuit by corrosion, taking into account refueling and shutdowns. The most difficult part of the calculation is to choose a value for the corrosion release rate of Inconel grids since there is no direct experimental evidence.

The value is inferred from analysis of the enhanced dose rates correlated with known instance of high cobalt contamination of Inconel grids. Since the latter are very imperfectly known, the range of answers is large. Further deductions of release rates can be made from the reduction in Co-58 inventories deposited on circuit surfaces that accompanies a change to Zircaloy grids. A range of release of 0.6-11 mdm with a best estimate of 2 mdm is deduced. This release information is used to calculate the incremental increase in dose rates caused by use of Inconel 718 (average coalt content) with respect to Zircaloy. Approximately a 15% reduction in unshielded dose rates by use of Zircaloy is predicted compared with plants which have used Inconel 718 with average levels of cobalt impurity. As this is nearly always within measuring erros within and between plants and dose rate fluctuation between different plants often exceed 15%, we do not feel it is surprising that no consistent evidence for a substantial reduction in dose rates through using Zircaloy has emerged. Evidence from those plants changing from Inconel 718 to Zircaloy well after initial start up is particularly slow due to the long half-life of Co-60. Other evidence was examined for a Zircaloy grid effect.

From the limited data available, release of Co-58/Co-60 at shutdown were not correlated with a change to zircaloy grids nor were radwaste outputs within the limits of statistical fluctuations in the data.

We concluded that the effect of dose rates was not liable to substantially exceed 15% with normally attainable cobalt impurity in Inconel 718 and could be lower with the particularly low cobalt inpurity levels demonstrably possible. Wide variations in shutdown releases and radwaste outputs were normally due to other causes than a change in Zircaloy.