NRC INSPECTION MANUAL

INSPECTION PROCEDURE 79702

CONTROL AND MONITORING OF RADIOLOGICAL SOURCE TERM

PROGRAM APPLICABILITY: 2515

79702-01 INSPECTION OBJECTIVES

01.01 To determine whether the licensee is adequately controlling the quality of plant primary and secondary systems and process water to minimize out-of-core radiation buildup.

01.02 To evaluate ALARA planning and controls, and provide additional guidance on evaluating licensee source term control programs.

79702-02 INSPECTION REQUIREMENTS

This procedure is implemented to independently assess licensee conclusions regarding extent of condition of issues, when selected as a part of supplemental inspections using IP 95002, "Supplemental Inspection For One Degraded Cornerstone or Any Three White Inputs in a Strategic Performance Area."

02.01 Implementation of the Source Term Control Program

a. Section 02.03 of the baseline inspection procedure for ALARA Planning and Controls, contains general guidance for assessing the status of the licensee's overall source term.

b. Determine if the licensee has developed an understanding of the plant source-term and whether there is a source-term control strategy. This strategy should consider:

   1. The reduction of cobalt containing components.

   2. An operating and shutdown chemistry control plan to minimize cobalt transport and crud bursts. This includes such activities as zinc injection (BWRs) or early boration (PWRs).

   3. Industry technologies such as Zinc Injection (BWRs),Noble Metal Chemistry (BWR), Hydrogen Water Chemistry (BWRs),

use of chromium coatings (PWRs) or Chemical Decontamination (PWRs/BWRs).

4. Preconditioning or electropolishing of reactor component surfaces to minimize the deposition of corrosion products.

5. System flushes to remove or reduce source term (e.g., hot spots).

c. Interview selected individuals (e.g., Operations Manager, Maintenance Supervisor) to verify that responsible staff are aware of this strategy and that is supported by plant management.

1. Determine if the licensee has established reasonable criteria to evaluate if the strategy is effective and is being implemented in a timely manner.

2. Review several significant source term reduction actions taken by the licensee (such as chemical decontaminations, replacement of cobalt containing valves, etc) and determine:

(a) If the action was performed in accordance with the overall strategy; and

(b) Its effect (if any) on the radiological source term.

d. Additionally, examine those actions proposed, but subsequently not approved by licensee management. Determine if these decisions were made within the strategy guidelines.

02.02 <u>Implementation of the Water Chemistry Control Program</u>

a. Determine whether the water chemistry control program is being implemented in accordance with existing policies and procedures. This review may include the following:

1. Reviews and discussions of the trends of recorded water quality data and reviews of these data by plant chemistry personnel.

2. Reviews of investigative (diagnostic) and corrective actions taken when chemical variables have exceeded the established levels or limits, including consideration of the timeliness of these actions.

3. Review and discussion of the effectiveness of measures taken to prevent the introduction of chemical contaminants into primary and secondary coolant water and to detect the presence of these contaminants.

4. Discussions with individuals at all levels (including plant operating and maintenance personnel) who are involved with water chemistry controls to determine whether they understand the need for, and importance of

these controls and whether individuals understand their roles in maintaining water quality. Corporate and plant management support and involvement are essential for success of the water chemistry control program.

5. Reviews and discussions of plant collective occupational dose (person-rem) as it relates to plant water chemistry control.

b. Determine if the licensee has established effective measures to control the potential increase of radiation fields from corrosion transport (i.e., crud bursts) occurring during plant shutdown and startup.

c. For BWRs utilizing Hydrogen Water Chemistry (HWC) determine if the plant has evaluated the optimal hydrogen injection rate and has developed a policy for minimizing cycling.

79702-03 INSPECTION GUIDANCE

General Guidance

This procedure includes inspection of both regulatory requirements and industry good practices, but emphasis is on the good practices that can result in large reductions in occupational radiation exposure. EPRI and industry research and infield trial/demonstrations is ongoing, and NRR and the Regions will continue to monitor and keep abreast of the latest, pertinent publications.

Specific Guidance

03.01 Implementation of the Source Term Control Program

The primary source of radiation fields in BWR and PWR nuclear power plants is Co-60. In PWRs, Co-58 can also be a significant radiation source early in plant life. However, after 10 effective full power years, Co-60 accounts for the majority of the radiation fields in PWRs due to its longer half-life.

Co-60 is formed as a result of neutron absorption by Co-59, the only cobalt isotope present in naturally occurring cobalt. Co-59 constitutes the major portion of many hardfacing materials (such as Stellite) used in nuclear plants. Co-58 is formed by neutron bombardment of nickel-58. Nickel is a major alloying constituent in many reactor coolant pressure boundary materials, such as PWR steam generator tubing.

Reducing the amount of cobalt available for irradiation is the soundest and most cost-effective means of controlling radiation fields. This is typically accomplished by:

a. Minimizing the amount of cobalt in system components, such as system valves, that can potentially reach the core. Typically, this is accomplished by identifying those components having the highest cobalt contribution potential and prioritizing them for replacement. For example, industry studies have shown that a significant reduction in BWR cobalt inventory can be achieved by replacing the control rod pins and rollers (typically containing high cobalt alloys) with low cobalt replacements.

b. Minimizing the amount of cobalt escaping to plant piping systems in the course of in-situ maintenance (e.g., valve maintenance), which some industry studies concluded accounts for about 10-30 percent of the cobalt entering the reactor system annually.

c. For BWRs, minimizing the amount of feedwater corrosion products by improving condensate polisher efficiencies, installing condensate filters, improving plant lay-up requirements, and/or eliminating corrosion product input into the condensate system.

   The industry has developed several alloys (such as EPRI's NOREM) that are suitable replacements for hardfacing alloys such as Stellite.

d. Use of sub-micron filtration of the reactor coolant system at power is a proven, effective way to minimize corrosion product deposition on primary plant component and piping surfaces.

03.02 <u>Implementation of the Water Chemistry Control Program</u>

Standard LWR Technical Specifications include limits and associated surveillance requirements on certain chemical variables in the primary coolant. The standard administrative controls section also contains a requirement that written procedures be established as recommended in Appendix A of Regulatory Guide 1.33, "Quality Assurance Program Requirements (Operation)." Regulatory Guide 1.33 includes "Chemical and Radiochemical Control Procedures" among the typical safety-related activities that should be covered by written procedures.

Compliance with NRC requirements will not ensure that water chemistry is adequately controlled (from an ALARA perspective) to reduce out-of-core radiation field buildup that may result in high occupational radiation exposures. The nuclear power industry, through its BWR and PWR owners groups and the Electric Power Research Institute (EPRI), has recognized the need for improved LWR water chemistry controls and has developed consensus guidelines for PWR and BWR primary and secondary water chemistry.

Control of PWR primary coolant water chemistry is essential if crud formation on the fuel and subsequent redeposition of radioactive oxides outside the core are to be minimized. The formation and stability of colloidal corrosion products are strongly affected by pH, and adsorption of cobalt on colloidal iron oxides is greatly increased at high pH. Cobalt solubility is greatest at low pH values (high boron, low lithium) and increases above the minimum at very high pH values (low boron, high lithium).

Industry experience has shown that for PWRs, the release of radioactive corrosion products during plant shutdown has been a significant contributor to radiation field buildup. The negative effects of these releases can be diminished by controlling the coolant chemistry to maximize the decomposition and solubilization of corrosion products. The PWR Primary Shutdown and Startup Chemistry Guidelines were developed by EPRI to provide an optimal strategy to minimize the radiological consequences, from the release of corrosion products.

Examples of some effective measures to reduce post-shutdown dose rates at PWRs are:

1. Early boration at shutdown to promote corrosion product solubility and aid in the release of corrosion products.

2. Slow plant cooldown rates with specific temperature hold points to maintain solubility of corrosion products, thus aiding in their removal via filtration and ion exchange.

3. Use of hydrogen peroxide to create an oxygenation crud burst, liberating corrosion products early on it the shutdown clean up process.

4. Use maximum primary clean-up purification flow to enhance corrosion product removal.

Radiation buildup in the BWR primary system occurs as the result of both soluble phase and particulate phase transport and deposition of activated species. Several industry initiatives have been developed, such as HWC, depleted zinc injection, noble metal chemistry, and control of feedwater iron, to reduce the transport of radioactive corrosion products. Guidelines for each of these topics can be found in the BWR Water Chemistry Guidelines and other related EPRI documents.

Frequently identified problems that resulted in poor water chemistry in operating BWRs include:

a. Improper operation of the condensate treatment system.

b. Improper operation of the reactor water cleanup system.

c. Leakage of condenser cooling water or air.

d. Inadequate design or maintenance of equipment.

e. Insufficient training or experience of plant personnel.

Ion–exchange resin ingress and condenser tube leaks have been found to be the principal recurring causes of off-standard water chemistry in BWRs. Ingress of resins into the reactor coolant system has caused more severe water chemistry transients than any other source. Transients resulting from ingress of resins or other organic materials been attributed, erroneously, to ingress of air (see memorandum from J. Wigginton to Regional Branch Chiefs, 04-15-83).

79702-04 RESOURCE ESTIMATE

It is estimated that 25-30 on-site inspector hours will be needed to complete this instruction. Multi-unit sites require the same amount of time.

79702 REFERENCES

EPRI TR-107991,"Radiation-Field Control Manual - 1997 Revision

EPRI TR-105714, "PWR Primary Water Chemistry Guidelines, Revision 3" 1995

EPRI RS-103515-R1, "BWR Water Chemistry Guidelines- 1996 Revision," 1996

NCRP report no. 120, "Dose Control at Nuclear Power Plants," (issued December 30, 1994).

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