U. S. NUCLEAR REGULATORY COMMISSION
REGION I

Report Nos. 50-317/87-25
50-318/87-26

Docket Nos. 50-317
50-318

License No. DPR-53
DPR-69

Priority --

Category C

Licensee: Baltimore Gas and Electric Company
P. O. Box 1475
Baltimore, Maryland 21203

Facility Name: Calvert Cliffs Nuclear Power Plant - Units 1 and 2

Inspection At: Lusby, Maryland

Inspection Conducted: November 30-December 4, 1987

Inspectors: Henry J. Bicehouse 12/22/87
H. Bicehouse, Radiation Specialist date

Approved By: W. J. Pasciak 12/28/87
W. J. Pasciak, Chief Effluents date
Radiation Protection Section

Inspection Summary: Combined Inspection on November 30,- December 4, 1987 (Combined Report Nos. 50-317/87-25 and 50-318/87-26)

Summary: The licensee's water chemistry control program (as it related to controlling corrosion and out-of-core radiation field buildup), was reviewed during this routine safety inspection.

Results: The water chemistry control program was acceptable and no violations of NRC requirements were observed.

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Details

1. Persons Contacted

1.1 Licensee Personnel

* J. Lemons, Manager, Nuclear Operations Department
  W. Cartwright, Senior Engineer, Chemistry
  P. Crinigan, General Supervisor, Chemistry
* R. DeAtley, Senior Engineer, Quality Assurance
  E. Eshelman, Chemist
  S. Hutson, Supervisor, Plant Chemistry
* J. Lenhart, Supervisor, Radiological Controls Operations
  J. Mihalcik, Principal Engineer, Fuel Cycle Management
  G. Phair, ALARA Supervisor
* L. Smialek, Senior Plant Health Physicist
* V. Tonty, Chemist
* B. Watson, Assistant General Supervisor, Radiological Controls
  P. Wright, Principal Radiation Safety Technician

Other licensee personnel were also contacted or interviewed.

1.2 NRC Personnel

* T. Foley, Senior Resident Inspector
* S. Sherbini, Senior Radiation Specialist
* D. Trimble, Resident Inspector
* A. Weadock, Radiation Specialist

* Attended the Exit Interview on December 4, 1987.

2. Scope

This routine safety inspection reviewed the licensee's water chemistry control program. The purpose of the inspection was to review the licensee's program to control corrosion and out-of-core radiation field buildup, ensure long-term integrity of the reactor coolant and secondary pressure boundaries and minimize fuel leakage caused by corrosion-induced failures. The licensee's program in these areas was reviewed relative to Technical Specifications, Final Safety Analysis Report (FSAR) commitments, NRC Regulatory Guidance and industry-consensus standards provided by the Electric Power Research Institute (EPRI).

3. Previously Identified Item

(closed) 25-00-13 TI-Trial use of water chemistry inspection modules
This inspection completed a series of inspections of the licensee's water chemistry control program which involved trial use of two inspection procedures.

4. Management Controls

The licensee's management controls, (i.e. organization, policies/procedures, training/qualification of personnel, review/audit activities) were reviewed relative to criteria, commitments and guidance provided in the licensee's Technical Specifications and referenced consensus standards, FSAR commitments and the following industry guidance documents:

- EPRI Report NP-4762-SR, "PWR Primary Water Chemistry Guidelines," (hereafter EPRI NP-4762), September 1986; and
- EPRI Report NP-5056-SR, "PWR Secondary Water Chemistry Guidelines - Revision 1,(hereafter EPRI NP-5056), March 1987.

4.1 Organization

The organization of the licensee's water chemistry control program was reviewed. The inspector noted that the licensee did not have a corporate group in water chemistry control. At the site, the Chemistry Unit (within the Nuclear Operations Department or NOD) provided both line and staff functions related to primary and secondary water chemistry control. The General Supervisor, Chemistry (reporting to the Manager, NOD) had overall responsibility for the program. Under the General Supervisor, the Supervisor, Plant Chemistry and his staff, (i.e. 2 Principal and 9 additional chemistry technicians) provided sampling and analyses of plant systems. Also reporting to the General Supervisor, the Supervisor, Water Treatment Group, his staff (i.e. 5 Water Treatment Technicians), provided sampling, analysis and operation of nonradioactive water treatment systems. Completing the line functions reporting to the General Supervisor, the Supervisor, Plant Labor and his 5 Plant Laborers provided support to the program including repair of condenser leaks.

Staff functions within the Chemistry Unit reported directly to the General Supervisor, Chemistry. Programmatic technical support, data trending and analysis, procedure development and review and limited audit functions were provided a staff consisting of a Senior Chemist, (vacancy during the inspection), two chemists, a chemical engineer, a chemistry technician and a data analyst. The inspector noted that the staff functions included roles performed in other utilities by site and corporate chemistry groups.

4.2 Policies/Procedures

The licensee's management policies relative to the water chemistry control program were reviewed to determine if the licensee had provided a management commitment to, and support for, an effective water chemistry control program. Although a clear corporate policy statement was not evident, the licensee had committed to implementing the intent of the guidelines in the EPRI reports (including power reductions or shutdowns for severe chemical transients) in response to a salt water intrusion in July 1981.

NRC Regulatory Guide 1.33, ("Quality Assurance Program Requirements-Operations"), recommends, in part, chemical and radiochemical procedures to prescribe the nature and frequency of sampling and analysis, instructions maintaining water quality within prescribed limits and limitations on concentrations of agents that may cause corrosive attack or fouling of heat transfer surfaces or that may become sources of radiation hazards due to activation. The Nuclear Steam Supply Systems (NSSS vendor), (i.e. Combustion Engineering Company) recommends control of certain impurities as a condition of the licensee's fuel warranty.

Licensee's procedures related to surveillance of water chemistry parameters in primary and secondary water systems, administrative control limits, sampling and analysis, in-line instrumentation calibration and maintenance, operation of each unit's water treatment and control systems, reporting/trending, valve maintenance and cleanliness control, record keeping and chemistry quality control were reviewed, discussed with selected members of the licensee's staff and checked for implementation by sampling chemistry records. Within the scope of this review, the licensee had developed and implemented adequate procedures consistent with Technical Specification requirements and EPRI guidelines. No specific concerns directly related to procedures were noted. However, cleanliness control implementation and monitoring of radiation field buildup appeared to be weaknesses which are discussed in subsequent details of this report.

4.3 Training/Qualification

The inspector briefly reviewed the licensees training requirements for chemistry personnel relative to ANSI N-18.1-1971 and EPRI guidelines. The licensee has developed and implemented a training program (including initial and continuing training) accredited by the Institute for Nuclear Power Operations (INPO). Discussions with Chemistry and Training personnel and review of records showed that an ongoing, comprehensive training program was being implemented.

4.4 Resources

The inspector reviewed station staffing relative to the identified duties and responsibilities of the Chemistry Unit. The licensee appeared to have sufficient technical staff to provide the sampling, analysis and surveillance activities described in the licensee's procedures.

The inspector also reviewed analytical capabilities relative to the EPRI guidelines and general Region I utilities capabilities. The licensee had state-of-the-art capabilities in the laboratory and was upgrading in-line instrumentation to a similar level.

4.5 Audits/Reviews

The inspector reviewed the licensee's audit program (as if related to water chemistry control) under the licensee's Technical Specifications and Quality Assurance Plan. The following audit reports were reviewed and discussed with the licensee:

- Audit No. 18-10-85, "Chemistry," April 1985;
- Audit No. 86-13, "Chemistry," March 17-April 10, 1986; and
- Audit No. 87-11, "Chemistry," March 24-April 15 and July 7 - August 14, 1987.

The audits reviewed administration of chemistry procedures, performance of chemical and radiochemical analyses and calibration of equipment but failed to systematically review the water chemistry control program as a whole.

During periods of plant operations, chemical measurements are summarized and reported to corporate management monthly. Discussions with chemistry personnel indicated that the monthly reports were reviewed and sometimes questioned by the Vice President, Nuclear Energy and others in the licensee's corporate level.

4.6 Trending Program

The licensee records data from the sampling and analysis program in a computer program which allows tabular and graphical presentation of trends.

5. Plant Water Chemistry Systems

5.1 Plant Description

Unit 1 is a two-loop, 850 MWe, Combustion Engineering (CE) Pressurized Water Reactor (PWR) which began commercial operation in May, 1975. Unit 2 is also a two-loop, 850 MWe, CE PWR which began commercial operation in April, 1977. Primary loop piping is stainless steel. No program to reduce cobalt alloys on the primary side has been undertaken. Fuel cladding is Zircalloy 4 and the fuel elements are conventional CE designs which can be disassembled by removal of the top restraints. The Chemical and Volume Control Systems (CVCS) use ordinary nuclear grade resins. On the secondary side, full-flow deep-bed condensate polishers are used on both units. Condenser-tubes on Unit 1 are Al 6x stainless steel with admirality brass tube sheets. Unit 2 tubes and tube sheets are titanium alloys. During the 1986 outage, the licensee completed removal of all major copper components from the Unit 1 feedwater and condensate systems. Following this replacement, feedwater heaters for both units are stainless steel. The moisture separator reheaters have been replaced with 439 stainless steel. Circulating condenser water is brackish (5,000 to 23,000 parts per million (ppm) saline) from the Chesapeake Bay. Precoat filter demineralizers are used to augment the full-flow condensate polishers. The licensee is completing installation of a nitrogen system on all condensate storage tanks to reduce auxiliary feedwater and condensate makeup oxygen levels. Steam generator blowdown is 275 gallons per minute (gpm) with blowdown recovery and 350 gpm without blowdown recovery for each unit. Blowdown amounts to approximately 1% of full steaming rate for each unit. Air inleakage in both condensers is less than 20 standard cubic feet per minute (SCFM).

5.2 Operation

The licensee's primary chemistry operating scheme was reviewed relative to guidelines in EPRI NP-4762. The licensee uses the "elevated lithium" operating scheme for coordination of lithium hydroxide and boric acid. In this operating scheme, lithium hydroxide is maintained at a constant 2.2 ppm as boric acid concentration is reduced from approximately 1200 to 200 ppm. Below 200 ppm boric acid concentration, lithium hydroxide concentrations are reduced from 2.2 ppm to 0.5 ppm. Primary pH values are maintained between 6.8 and 7.4. Reducing conditions are maintained by hydrogen addition. The licensee's operating scheme is consistent with consensus guidelines in EPRI NP-4762.

The licensee's secondary chemistry operating scheme was reviewed relative to guidelines for recirculating steam generators in EPRI NP-5056. Both units have been operated with all-volatile treatment (AVT) since initial operation. Ammonia or hydrazine from the chemical addition system is added downstream of the condensate demineralizer system. Layup, startup and full-steaming operational standards were consistent with EPRI NP-5056. The licensee was testing morpholine treatment on Unit 2 to reduce sludge pile buildup. Demineralizer resins were regenerated with an operating life from 12 to 14 days. Demineralizer resins were regenerated on ammonium, carbonate and/or bicarbonate ion breakout. Filter demineralizer changes were predicated on increased differential pressure.

6. Sampling/Measurement

The licensee's reactor coolant, steam generator and reactor coolant makeup sampling systems were reviewed relative to commitments in the units' FSARs and industry-concensus recommendations and guidelines. The review included frequency of surveillance of in-line instrumentation, sample stream temperature control, quality control of inline instrumentation accuracy, acceptance and correction criteria for conductivity and cation conductivity measurements, ranges of inline instrumentation, sample line valve operation and radiological control of sampling operations. Primary and secondary sampling panels for both units were observed and their operation discussed with chemistry technicians.

Within the scope of this review, no deviations from licensee commitments were noted. However, the Unit 2 primary sample panel showed increased radiation levels due to fuel failure in Unit 2. The area radiation monitor (ARM) for the Unit 2 Sample panel area was in alarm, (greater than 10 millirem per hour (mrem/hr) radiation levels at the ARM). Comparable radiation levels at the Unit 1 primary sample station were approximately 4 mrem/hr. Surveys of the Unit 2 panel showed the fields to be 20-30 mrem/hr and discussions with radiation protection personnel indicated that the fields were increasing and the licensee was planning high radiation area control procedures should the fields reach 100 or more mrem/hr.

7. Implementation

The licensee's implementation of the water chemistry control program was reviewed relative to Technical Specifications, recommendations and guidance in NRC Regulatory Guides and industry consensus standards.

7.1 Surveillances

Under Technical Specification 3/4.4.7, "Chemistry", the licensee is required to determine dissolved oxygen, chloride and fluoride concentrations in the Reactor Coolant System at least once per 72 hours. Chemistry surveillance records during periods of operation for both units in 1986 and 1987 were reviewed to determine if the surveillance frequency had been met and if any of the parameters had exceeded steady state or transient limits. Within the scope of this review, no violations were noted.

The licensee's general chemistry sampling and analysis program for control and diagnostic parameters in the units' primary and secondary sides was reviewed relative to the licensee's procedures. Chemistry log sheets and other records for January 1 through September 30, 1986 and July 1 through November 30, 1987 were reviewed to determine that sampling frequencies and analyses as specified in procedures had been met and if any unusual concentrations had been noted that they were investigated by the licensee. Within the scope of this review, no violations were noted.

7.2 NRC Bulletin No. 87-01

The licensee has experienced erosion/corrosion phenomena in carbon steel feedwater piping. The licensee has been monitoring feedwater piping for about 8 years and has replaced sections of feedwater carbon steel piping with erosion/corrosion resistant chromium-molydenum alloy pipe as thinning (or incipient failure) became apparent. Unit 1 inspections in April 1985 and November 1986 identified erosion/corrosion opposite branch connections, downstream of valves and orifices, on turbine blades and a slight erosion of the low pressure casing inlet to the turbine. Unit 2 inspections in May 1984, November 1985 and April 1987 noted erosion/corrosion opposite branch connections, downstream of valves and orifices, and on turbine blades. On September 24, 1987, the licensee provided summary feedwater and condensate chemistry data in response to the questionaire in NRC Bulletin No. 87-01. The inspector reviewed feedwater and condensate chemistry data on a sampling basis and determined that the data reported in the licensee's response was representative of recent chemistry measurements.

7.3 Fuel Integrity

The fuel cladding, used to contain the fuel pellets within the fuel rod, forms the first barrier against the release of the radioactive fission product formed during reactor operation. EPRI NP-4762 lists dissolved oxygen, fluoride, aluminum, calcium, magnesium, silica, suspended solids and pH as key chemistry parameters requiring control to minimize fuel integrity concerns. The inspector reviewed chemical and radiochemical data and discussed recent fuel experience with the licensee to determine if the licensee's chemistry control program minimized fuel integrity concerns.

The recent experience with fuel failures for the two units is summarized below (based on discussions with the licensee's Fuel Management Group):

Unit	Cycle	No. Failed Pins	Suspected Cause
1	7	No data	No data
1	8	9	8 "Fretting"+1"hybriding"
1	9	0	NA
2	5	4	unknown
2	6	No data	No data
2	7	6	5 "Fretting"+ 1 unknown
2	8	12-16	"Fretting" suspected

Note: "Fretting" is a licensee term for failure attributed to incore debris-induced clad thinning and subsequent hybriding of the Zircaloy once the cladding is breached.

Review of recent radiochemical data from Unit 2 showed higher than expected radioiodine concentrations. In PWR plants, the amount of Iodine-131 and Iodine-133 is proportional to the recoil process, the presence of defects and the removal rate of the CVCS. The "iodine ratio" (i.e. the ratio of Iodine-131 to Iodine-133) can be calculated on a plant specific basis and compared to the measured iodine ratio from radiochemical data at steady-state operation. If the measured ratio is greater than the calculated plant value, a non-recoil source is indicated which is likely to be defective fuel. Review of the Unit 2 radiochemical data from July-November 1987 showed a measured iodine ratio greater than the calculated plant value indicative of failed fuel. However, the iodine ratio does not give any additional information concerning the size or quantity of the fuel defects. Operational experience has shown that fuel defects larger than pinholes are likely to show soluble fission product activities in the coolant (including the radiocesium isotopes). Unit 2 radiochemical data showed cesium-134 to be present as well as the radioiodines. The inspector concluded from this data that fuel failure was occurring in Unit 2.

The inspector reviewed chemical data for Unit 2 for dissolved oxygen, fluoride and pH from July through November 1987 to determine if the Unit 2 fuel failure was reasonably attributable to corrosion fluoride attack or lower than normal pH. Comparisons of Unit 1 and Unit 2 chemical data were also completed. No unusual chemical concentrations were noted. No significant differences between the two units chemistry values were identified. The inspector concluded that chemical-induced failure was unlikely.

7.4 Radiation Field Buildup

The primary long-term source of radiation fields in PWRs is Cobalt-60, formed by neutron capture by Cobalt-59. Cobalt-58, formed by the Nickel-58 (neutron-proton) reaction with fast neutrons, is the second important contributor to out-of-core radiation fields at PWRs. The major source of nickel is corrosion of alloy 600 steam generator tubing. Cobalt sources include cobalt as an impurity in alloy 600 tubing, corrosion and wear of high cobalt alloys and corrosion release of cobalt from stainless steel piping and reactor vessel internals. EPRI NP-4762 suggests that controlling lithium hydroxide and boric acid to either maintaining an elevated lithium or a constant pH operating scheme is an acceptable way to control the growth of out-of-core radiation fields. The licensee consistently operated both units in the elevated lithium scheme. A useful indication of relative effectiveness of a licensee's control of out-of-core radiation field buildup is to compare steam generator channel head radiation levels to PWR averages for comparable equivalent full power years of plant operation. On that basis, the licensee's program has achieved consistantly lower steam generator channel head radiation levels (8-10R/hr) than the comparable PWRs (25-35R/hr).

7.5 Steam Generators (SG)

CE manufacturers a standard vertical recirculating U-bend tubed steam generator with different models based on the number of tubes required by the thermal output of the plant. CE steam generators have experienced denting, thinning, intergranular attack/stress corrosion cracking (IGA/SCC) and pitting on the secondary site.

Denting is the most prevalent problem noted. Denting stems from the corrosion of carbon steel support structures within the SG, (i.e. support plates, "eggcrates" and the tube sheet). The corroded carbon steel undergoes a phase change to magnetite which has approximately twice the volume as the original source material. Continued growth of the corrosion product fills the gap between the support plate and its tube causing denting of the tube. Continued denting can result in cracked tubes and support plate ligaments. Minor denting has been noted in examinations of the licensee's four SGs. The presence of copper species are known to promote denting. As noted earlier, the licensee has removed major copper sources from the secondary loops. General corrosion control is dependent on maintenance of low oxygen concentrations. The licensee has been maintaining low feedwater and condensate oxygen levels. Condensate polishers and filter demineralizers in the secondary further reduce chemical species and provide additior] SG protection. The licensee's design provided full-flow condensate polishing. Review of licensee chemical data showed condensate and feedwater and blowdown concentrations consistently within guidelines of EPRI NP-5056.

7.6 Primary-To-Secondary Leakage

The steam generator tubes provide a barrier between radioactivity in the primary system and the secondary condensate water and environment via the condenser off-gas system. Technical Specifications require the licensee to measure the primary-to-secondary leakage rate and maintain it within regulatory limits. Four basic parameters can be used to monitor steam generator integrity during operation:

- pressurizer level (for gross leaks);
- secondary water radioactivity measurements;
- secondary water dissolved chemicals (e.g. boric acid or pH/conductivity measurements); and
- air ejector and SG blowdown radiation monitors.

In view of the apparent fuel leak in Unit 2, the inspector reviewed the licensee's methods for determining primary-to-secondary leakage rates and the licensee's current estimates of those leakage rates. The licensee uses radioactivity measurements in the offgas and secondary water for the leakage determination. The inspector noted that the Unit 2 offgas monitor showed no appreciable increase despite the increased radioiodines and other radionuclides in the primary water. Unit 2 secondary water radioiodines remained low and indistinguishable from previous cycles. The licensee estimated a Unit 1 primary-to-secondary leakage rate of about 10 gallons per day and a Unit 2 rate of zero. The surveillance frequencies and measured leakage rates were within regulatory requirements.

8. Exit Interview

The inspector met with the licensee's representatives (denoted in Detail 1) at the conclusion of the inspection on December 4, 1987. During the meeting, the inspector summarized the purpose and scope of the inspection, identified findings and expressed concern over the Unit 2 fuel failure. The licensee's representative indicated that the licensee shared the concern and was considering a Unit 2 outage to correct the fuel problem.

At no time during this inspection was written material provided to the licensee by the inspector. No information exempt from disclosure under 10 CFR 2.790 is discussed in this report.