ArevaEPRDCPEm Resource

From: Carneal, Jason
Sent: Monday, July 12, 2010 2:54 PM
To: Tesfaye, Getachew
Cc: Lu, Shanlai; Budzynski, John
Subject: Excore audit plan July 13-14 2010.docx
Attachments: Excore audit plan July 13-14 2010.docx

Getachew:

Attached is the final audit plan for the ex-core detector audit. Please transmit the final plan to AREVA and add the file to ADAMS.

Thanks,

Jason

Hearing Identifier: AREVA_EPR_DC_RAIs
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Subject: Excore audit plan July 13-14 2010.docx
Sent Date: 7/12/2010 2:54:11 PM
Received Date: 7/12/2010 2:54:20 PM
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MESSAGE	176	7/12/2010 2:54:20 PM
Excore audit plan July 13-14 2010.docx	194698	

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AUDIT PLAN TO REVIEW SELECTED AREAS RELATED TO
U.S. EPR FSAR CHAPTER 4.4 SAFETY EVALUATION

APPLICANT:	AREVA NP, Inc.
APPLICANT CONTACT:	Martin Bryan Jerry Holm
TIME:	8:30 am to 4:30 pm on 7/13/2010 8:30 am to 12:00 pm on 7/14/2010
LOCATION:	AREVA NP Inc. 3315 Old Forrest Road P.O. Box 10935 Lynchburg, VA, 24506-0935
REVIEWERS:	John Budzynski (NRO, Audit Lead and Reviewer) Jose A. March-Leuba, ORNL (Consultant, ORNL) Randy Belles, ORNL (Consultant, ORNL) Shanlai Lu (NRO) Jason Carneal (NRO) Getachew Tesfaye (NRO)

BACKGROUND

Ex-core neutron detectors have been used for many years to control and protect pressurized water reactors. They are placed outside the vessel and have very large cross sections so they can be used not only during full power operation, but also at source level during startup. For EPR, the protection during low-power operations is ensured solely by the ex-core detectors. At full power operations, the self-powered neutron detectors (SPNDs) and AMS system are operational and are used to protect the reactor from exceeding design thermal limits, in addition to the ex-core detectors. The SPNDs do not have sufficient sensitivity at startup power levels.

The heavy neutron reflector is designed to improve the neutronics inside the core and to reduce the gamma and neutron fluxes outside the reactor core, thus reducing the fluence at the reactor vessel (i.e. radiation damage). As the result, the neutron flux level outside of the EPR reactor vessel is estimated to be one magnitude lower than that of a typical operating PWR. Since the reactor protection system relies on the ex-core detectors to trip the reactor during AOOs and postulated accidents, which are listed in the attached tables, it is important to ensure that the ex-core detectors are sensitive enough to detect the neutron flux that reaches them and are calibrated properly to correlate the measured ex-core neutron flux with the core power level and power distribution. It is also important to assess the effect the reflector might have on the transient response of the detectors. It is foreseen that these issues may be particularly relevant during refueling operations and start-up, corresponding to the lowest neutron fluxes, when the source range detectors are in use.

PURPOSE AND APPROACH

The purpose of this audit is to review additional documents provided by AREVA that pertain to the safety evaluation of the ex-core neutron flux detector design and operational issues due to the presence of the heavy neutron reflector. The specific issue of concern is that sufficient detailed information of the ex-core neutron flux detector has not been provided to perform an adequate safety evaluation.

The staff intends to audit documents related the ex-core neutron flux detector design, operations, maintenance, and sensitivity studies under normal and adverse conditions related to U.S. EPR FSAR Chapters 4. To achieve the review goals in an efficient manner, the staff has assembled an interdisciplinary audit team consisting of professionals with expertise in the reactor core instrumentation and monitoring, and reactor physics areas. The audit team will include experts from NRC and consulting organizations. To facilitate and expedite the work, it is foreseen that the audit will be attended by representatives from AREVA who will also introduce the audit topics along with the supporting documents and technical evidence to the reviewers. The staff will document the audit findings in an audit report that will contain proposed RAIs.

AUDIT ACTIVITIES AND SCHEDULE

The NRC staff and the experts from the consulting organizations will conduct the review over a period of one business day. NRC may request an ad-hoc extension of the audit at the same location if findings during the ongoing audit reveal the need for additional time. Such an extension will be requested before noon time on 05/07/2010, by the NRC staff responsible for the audit.

Following the audit, each technical reviewer will prepare a separate audit report with specific findings and proposed RAIs and will send the report to J. Budzynski by 05/30/2010. The NRC staff responsible for the audit will assemble and prepare a final audit report. This final audit report will contain a section that lists all proposed RAIs. The final report will be made available to all contributors for their concurrence by 6/30/2010.

A detailed agenda for the audit is presented in Table 1 of Attachment A. The specific audit areas, supporting technical documentation and responsible reviewers are identified in Table 2 of Attachment A.

If necessary, any circumstances related to the conductance of the audit will be communicated to J. Budzynski (NRC) at 301-415-1979 or at john.budzynski@nrc.gov.

ISSUES

To evaluate the impact of the heavy metal reflector on ex-core detector performance, the following issues should be addressed properly by AREVA.

<u>Ex-Core Neutron Flux Level</u>

1. What is the estimated neutron flux level at locations where ex-core detectors will be installed?
2. How are the gamma, fast, and thermal neutron fluxes affected by the reflector?

   a. During power operation
   b. During power ascension
   c. At source level or hot shutdown operations before criticality is reached on the final approach to criticality
3. What is the method used to predict the ex-core neutron flux level? Has it been benchmarked and validated against experimental data? How is the heavy reflector modeled to accurately predict the attenuation effect for gamma, fast and thermal neutrons?
4. Provide a detail explanation of the algorithm used in the NEMO-K code in regard to detector response.

Ex-Core Detector Design

5. What is the sensitivity of the ex-core detector to gammas, fast neutrons and thermal neutrons? What are lowest gamma and neutron flux threshold for these detectors?
6. At what neutron/gamma flux level will the detector transfer from “current-mode” to “pulse-mode”?
   a. What is the equivalent power level for this mode transition?
   b. Is this transition power low enough for startup operations at source level?
   c. What will be the process of ex-core detector calibration for the first reactor startup before calorimetric measurements are available?
7. Will the source range detectors have enough sensitivity to protect against a positive criticality insertion accident from low in the source range?

Transients and Accidents Requiring Ex-Core Neutron Flux Trip

8. Since the reflector has the potential to reduce the ex-core neutron flux by as much as a factor of 10 with respect to operating reactor experience, can an over-power condition be reached during the initial startup?
9. For all the reactor trips requiring ex-core detector response, have they been analyzed considering the existence of heavy reflector? What is the impact?
10. Has the trip set point methodology been developed to take into account the ex-core detector response time and threshold value affected by the heavy reflector?

Ex-core Instrumentation Systems (EIS) for EPR (DCD Ch. 7.1)

8 Power Range Detectors (PRD)
Uncompensated, boron lined ionization chamber detectors
Locations: 45°, 135°, 225°, 315°
Two stacked at each location, for lower and upper core monitoring
Range: 10^{-1} % to 200 % of rated power (upper 3 decades)

4 Intermediate Range Detectors (IRD)
Gamma compensated, boron lined ionization chamber detectors
Locations: 45°, 135°, 225°, 315°
Range: 10^{-4} % to 100 % of rated power (7 decades up to at least 60% power)

3 Source Range Detectors
Boron lined proportional counter detectors
Locations: 0°, 90°, 270°

Range: 10^{-8} % to 10^{-2} % of rated power (lower 6 decades, overlapping IRD range by 2.5 decades)

<u>Heavy Reflector for EPR (DCD Ch. 4.3)</u>

The U.S. EPR reflector consists of a large steel structure, varying in thickness from 4 to 8 in, with flow channels for cooling. The overall composition of the reflector is 95% metal and 5% water. There is a thin water region between the core and reflector. This configuration minimizes the thermalization of neutrons leaving the core while reflecting more fast neutrons back into the core than is possible with standard reflector geometries.

The neutronic treatment of the heavy reflector is similar to that used for standard reflectors, in that transport theory calculations are performed to generate a set of equivalent reflector cross sections for different zones around the reflector.

Reactor Trips Relying on EIS for EPR (DCD Ch. 15.0)

Signal[4]	Setpoint[1] (Nominal)	Uncertainty (Normal/Degraded)	Time Delay[2] (s)
Excore high neutron flux rate of change	11% NP	2% NP	0.7
High core power level	105% NP	10.2% NP/11.7% NP	0.9 plus sensor delays
High neutron flux (IR)	15% NP	10% NP	0.7
Low neutron flux doubling time (IR)	20 s	10 s	0.7

Incident	Reactor Trip Functions[1]	ESF Functions[2]	Other Equipment
15.1 Increase in Heat Removal by Secondary System			
Decrease in feedwater temperature	• Low DNBR • High LPD • High core power		
Increase in steam flow	• Low DNBR • High LPD • High core power • Low SG pressure • High SG P	• MFW/SSS isolation on low SG pressure or high SG ΔP • SIS and partial cooldown on low RCS pressure • MSIV closure on low SG pressure or high SG ΔP	
Inadvertent opening of a SG relief or safety valve	• Low DNBR • High LPD • High core power • Low SG pressure • High SG ΔP	• MFW/SSS isolation on low SG pressure or high SG ΔP • SIS and partial cooldown on low RCS pressure • MSRT isolation on low SG pressure • MSIV closure on low SG pressure or high SG ΔP	

Steam system piping failure	• High core power • Low DNBR • High LPD • Low SG pressure • High SG ΔP	• MSIVs closure on high SG ΔP or low SG pressure • Affected SG MFW/SSS isolation on high-high SG ΔP or low-low SG pressure • Unaffected SG MSRTs opening on high SG pressures • Stuck-open-MSRCV MSRT isolation on low-low SG pressure • SIS and partial cooldown on low-low PZR pressure, or SIS on low margin to RCS saturation	
15.4 Reactivity and Power Distribution Anomaly			
Uncontrolled RCCA bank withdrawal from a subcritical or low power startup condition	High flux rate (PR)		
Uncontrolled RCCA bank withdrawal at power	• Low DNBR • High LPD • High core power • High flux rate (PR)		
Inadvertent decrease in the boron concentration in the RCS	• Low DNBR • High core power		Anti-dilution
RCCA ejection	• High flux rate (PR) • High flux (IR)		

Attachment A

Table 1: Audit Agenda

Item No.	Time	Item	Responsible
		7/13/2010	
1	8:30-8:35 am	Opening remarks, presentation of participants, organizational questions	J. Budzynski (NRC)
2	8:35am -12:00 pm	Presentation by AREVA on ex-core neutron flux detector design, operation and maintenance.	AREVA
3	12:00	Lunch	All
4	1:00-4:00 pm	Review of Technical Documentation	NRC staff and external experts
		7/14/2010	
5	8:30 am - 11:30 pm	Review of Technical Documentation	NRC staff and external experts
6	11:30 am - 12:00 pm	Audit Summary and Exit Meeting	All

Table 2: Audit Areas, Supporting Technical Documentation and Responsible Reviewer

Item No.	Audit Area	Supporting Documentation	Responsible Reviewer
1	Design, operational, and maintenance details of the ex-core neutron flux detector.	(1) Detailed drawing; (2) Detailed specifications; (3) Manufacturing process: dimension tolerance, initial testing procedures; (4) Calibration requirements; (5) Aging and service time requirements; (6) Operating fleet ex-core detector; (7) Detector response code algorithm; (8) Uncertainty calculation.	John Budzynski Jose March-Leuba Randy Belles Shanlai LU Ken Mott