LICENSE AMENDMENT REQUEST TO CHANGE TECHNICAL SPECIFICATIONS IN SUPPORT OF PRNM AND ARTS / MELLLA IMPLEMENTATION
Enclosure 2 – Attachment 10

NEDO-33690, Revision 0

Columbia Generating Station Power Range Neutron Monitoring System Response Time Analysis Report

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(non-proprietary version)

HITACHI

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Columbia Generating Station Power Range Neutron Monitoring System Response Time Analysis Report

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ACRONYMS AND ABBREVIATIONS

Term	Definition
APRM	Average Power Range Monitor
ASP	Automatic Signal Processor
BTP	Branch Technical Position
CGS	Columbia Generating Station
FDDI	Fiber Direct Data Interface
FSAR	Final Safety Analysis Report
GEH	GE-Hitachi Nuclear Energy Americas LLC
GGNS	Grand Gulf Nuclear Station
IEEE	Institute of Electrical and Electronics Engineers
I&C	Instrumentation & Control
ISG	Interim Staff Guidance
LPRM	Local Power Range Monitor
NUMAC	Nuclear Measurement Analysis and Control
NRC	Nuclear Regulatory Commission
NUREG	Nuclear Regulatory Commission Regulation
OPRM	Oscillation Power Range Monitor
PRNMS	Power Range Neutron Monitoring System
RAI	Request for Additional Information
RPS	Reactor Protection System
STP	Simulated Thermal Power
V&V	Verification & Validation

EXECUTIVE SUMMARY

This report evaluates the Response Time of the Columbia Generating Station (CGS) Nuclear Measurement Analysis and Control (NUMAC) Power Range Neutron Monitoring System (PRNM) system versus the safety analysis requirements and standard criteria for digital instrumentation and controls. This evaluation demonstrates compliance with the criteria of Branch Technical Position (BTP) 7-21 and Staff Positions 1.19 and 1.20 of Digital Instrumentation & Control-Interim Staff Guidance (DI&C-ISG-04).

1. INTRODUCTION

This report describes the PRNM system response time in support of the four safety-related trip signals. As defined by Section 3.3.2 of Reference 1, "The safety functions of the PRNM system are:

- Average Power Range Monitor (APRM) Neutron Flux – High Trip
- APRM Simulated Thermal Power (STP) – High Trip
- APRM Neutron Flux – High (Setdown) Trip
- Oscillation Power Range Monitor (OPRM) Instability Detect-and-Suppress Trip"

The CGS PRNMS uses the OPRM Option III algorithm described in Section 3.3 of Reference 1, which is the licensing basis for the CGS NUMAC PRNM. The approach used for the response time analysis presented in this report is similar to the one previously presented to the U.S. Nuclear Regulatory Commission (NRC) for the Grand Gulf Nuclear Station PRNMS project, via responses to RAIs 18 and 20 within Reference 2.

This evaluation addresses the criteria of BTP 7-21, and demonstrates compliance with these requirements. Secondly, this analysis addresses Staff Positions 1.19 and 1.20 of DI&C-ISG-04 for the CGS PRNM.

Plant specific requirements for time response issues are directly addressed in table items 8.3.4.4.4, 8.4.4.4.4 and 8.5.4.4.4 of Reference 3.

2. CGS PRNM RESPONSE TIME ANALYSIS

2.1 Analysis Approach

This evaluation addresses the criteria of BTP 7-21, and demonstrates compliance with these requirements. Secondly, this analysis addresses Staff Positions 1.19 and 1.20 of DI&C-ISG-04 for the CGS PRNM.

2.2 Evaluation per BTP 7-21 Requirements

Real-Time Performance Methodology

The instrument response time performance determination for the PRNM is performed by tracking the signal flow from the Local Power Range Monitor (LPRM) input at PRNM, through the LPRM and APRM instruments, ending at the output of the 2-Out-Of-4 Logic Module's Relay Logic Cards output to the Reactor Protection System (RPS), and calculating the design goal processing time delay for each step of the signal transfer process. Figure 2.2-1 provides a block diagram for a single APRM channel.

Response Time Start and End Events

The LPRM detector input exceeding the respective setpoint is the start event of the NUMAC PRNM response time, and the Relay Logic Card module trip signals to RPS is the end event for response time determination.

Response Time Performance

Table 2.2-2 provides a tabulation of the PRNM instrument processing delay times associated with supporting each of the safety functions identified above. The total channel response (delay) time for the safety functions are calculated by applying the methodology as described above. The longest path of flux data for inclusion in the channel calculations is at the input of the LPRM instrument, processing through the APRM instrument, then output from the 2-Out-Of-4 Logic Module. [[

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Table 2.2-1 provides a summary of the PRNM response time requirements (per Section 3.3.2 of Reference 1) and the calculated PRNM response times (per Tables 2.2-2 and 2.2-3). This is the total delay time for PRNM to send a trip signal to RPS in response to a flux input that exceeds the setpoint.

Table 2.2-1 Safety Function Response Times

PRNM Safety Function	PRNM Response Time Requirement (mSec)	PRNM Calculated Response Time (mSec)
APRM Neutron Flux – High Trip	40	[[
APRM STP – High Trip	40	
APRM Neutron Flux – High (Setdown) Trip	40	
OPRM Instability Detect-and-Suppress Trip	400	]]

Tests were performed during PRNM System Validation and Factory Acceptance Testing, to confirm the Columbia PRNM system configuration meets the response time requirement. Testing was performed on production (non-development) equipment manufactured in accordance with the Columbia design documentation.

In summary, the calculated PRNM response times, presented in Talbe 2.2-1, meet the requirement of a response time analysis report as stated in Section D.9.4.2.4 of DI&C-ISG-06. Confirmation of response time was performed during verification and validation (V&V) testing.

RPS Response Time Requirement

As identified in Table 1.3.1.1-1 of Reference 4, the RPS response time requirement for the APRM Fixed Neutron Flux – High scram function is 0.09 seconds. The 0.09 second (90 millisecond) RPS response time for this function is used in the transient analysis for the Columbia Final Safety Analysis Report (FSAR) Chapter 15 Accident Analyses (Table 15.0-2, Item 33 of Reference 5). Chapter 15 does not credit OPRM functions in the transient analyses, so its response time is not discussed in the context of total RPS response time.

Per Note 17 on page 22 of Reference 6, the trip logic and scram contactor response time is 50 milliseconds. The sensor contact for the NUMAC PRNM system is the RPS Relay Logic Card contacts in the 2-Out-Of-4 Logic Module. The 40 millisecond response time of NUMAC PRNM plus the 50 millisecond RPS response time support the 90 millisecond total RPS response time requirement assumed in the Reference 5 safety analyses.

In summary, the response time for the PRNM has been shown by analysis and testing to be less than the required response times, and thus, the PRNM performs sufficiently to meet safety analysis requirements. There is no change in the total RPS response time requirement; therefore, there is no change in setpoint analyses for the CGS NUMAC PRNM due to response time. The NUMAC PRNM response time is adequate to meet the Limiting Response Time of RPS consistent with the guidance provided in Nuclear Regulatory Commission Regulation (NUREG)-0800 and BTP 7-21.

Institute of Electrical and Electronics Engineers (IEEE) 603-1991 Clause 4.10 (Reference 7) requires the safety system design basis to include the critical points in time or the plant conditions, after the onset of a design basis event, including:

1) The point in time or plant conditions for which the protective actions of the safety system shall be initiated.

2) The point in time or plant conditions that define the proper completion of the safety function.

3) The points in time or the plant conditions that require automatic control of protective actions.

4) The point in time or the plant conditions that allow returning a safety system to normal.

With respect to system response time, the CGS FSAR (Reference 5) Chapter 15 requirements use the timing requirements from the Licensee Controlled Specification Manual (Reference 4) Table 1.3.1.1-1. This meets the IEEE-603-1991 Clause 4.10 (Reference 7) requirement for the safety system design basis.

Figure 2.2-1 APRM Channel Response Time Performance Block Diagram

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Table 2.2-2 APRM Channel Flux Trip Delay Time Analysis

APRM Neutron Flux – High Trip, APRM Neutron Flux High – High (Setdown) Trip & APRM STP – High Trip	
Processing Step	**Time (msec)**
[[	
	]]

Table 2.2-3 OPRM Trip Delay Time Analysis

OPRM Trip	
Processing Step	**Time (msec)**
[[	
	]]

2.3 Evaluation per Staff Positions 1.19 and 1.20 of DI&C-ISG-04

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Staff Position 1.19:

If data rates exceed the capacity of a communications link or the ability of nodes to handle traffic, the system will suffer congestion. All links and nodes should have sufficient capacity to support all functions. The applicant should identify the true data rate, including overhead, to ensure that communication bandwidth is sufficient to ensure proper performance of all safety functions. Communications throughput thresholds and safety system sensitivity to communications throughput issues should be confirmed by testing.

The following explains how the PRNM system satisfies the criteria of Staff Position 1.19. This report discusses the features used to ensure sufficient link capacity, identifies link capacity, and details testing performed to ensure communication links have sufficient capacity to ensure proper performance of safety functions.

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Table 2.3-1 FDDI Link Capacity Usage

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The PRNM system communication link features, capacity usage information, and testing described above satisfy the criteria of Staff Position 1.19.

Staff Position 1.20:

The safety system response time calculations should assume a data error rate that is greater than or equal to the design basis error rate and is supported by the error rate observed in design and qualification testing.

The following explains how the PRNM system satisfies the criteria of Staff Position 1.20. [[

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Table 2.3-2 Data Error Rate Effect to PRNM System Response Time

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Table 2.3-3 Maximum Expected PRNM System Response Time

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The data error rate for each safety-related communication link was established and used to determine the effect of data errors on safety system response time. The established data error rates will be supported by testing a similar PRNM system for GGNS during integration testing. Therefore, the criteria of Staff Position 1.20 are met.

3. SUMMARY & CONCLUSIONS

This report evaluates the response time of the CGS PRNM versus the safety analysis requirements and standard criteria for digital instrumentation and controls. This evaluation demonstrates compliance with the criteria of BTP 7-21 and Staff Positions 1.19 and 1.20 of DI&C-ISG-04.

Plant specific requirements for time response issues are directly addressed in table items 8.3.4.4.4, 8.4.4.4.4 and 8.5.4.4.4 of Reference 3.

4. REFERENCES

1. GE Nuclear Energy, "Nuclear Measurement Analysis and Control Power Range Neutron Monitor (NUMAC PRNM) Retrofit Plus Option III Stability Trip Function, Licensing Topical Report," NEDC-32410P-A,Volumes 1 & 2, October, 1995 (Including Supplement 1, November, 1997).

2. Correspondence from Michael Krupa (Entergy Operations, Inc.), to U.S. Nuclear Regulatory Commission, GNRO-2011/00039, dated May 26, 2011 (ML111460590).

3. GE Hitachi Nuclear Energy, "Columbia Generating Station Plant-Specific Responses Required by NUMAC PRNM Retrofit Plus Option III Stability Trip Function Topical Report (NEDC-32410P-A)," 0000-0101-7647-R3, dated October, 2011.

4. Columbia Licensee Controlled Specifications Manual

5. Columbia Final Safety Analysis Report

6. GE Nuclear Energy, Reactor Protection System Design Specification Data Sheet, 23A1877AA, Revision 3.

7. IEEE 603-1991, IEEE Standard Criteria for Safety Systems for Nuclear Power Generating Stations.