Britt T. McKinney
Sr. Vice President & Chief Nuclear Officer

PPL Susquehanna, LLC
769 Salem Boulevard
Berwick, PA 18603
Tel. 570.542.3149 Fax 570.542.1504
btmckinney@pplweb.com

FEB 28 2006

U.S. Nuclear Regulatory Commission
Attn: Document Control Desk
Mail Stop OP1-17
Washington, DC 20555-0001

SUSQUEHANNA STEAM ELECTRIC STATION
PROPOSED LICENSE AMENDMENT
NUMBERS 272 FOR UNIT 1 OPERATING LICENSE NO. NPF-14
AND 241 FOR UNIT 2 OPERATING LICENSE NO. NPF-22
POWER RANGE NEUTRON MONITOR SYSTEM
DIGITAL UPGRADE
RESPONSE TO NRC QUESTIONS
SUPPLEMENTAL INFORMATION NO. 2 **Docket Nos. 50-387**
PLA-6012 **and 50-388**

Reference: 1) *PLA-5880, B. T. McKinney (PPL) to Document Control Desk (USNRC), "Susquehanna Steam Electric Station Proposed License Amendment No. 272 for Unit 1 Operating License No. NPF-14 and 241 for Unit 2 Operating License No. NPF-22 Power Range Neutron Monitor System Digital Upgrade," dated June 27, 2005.*

2) *NRC Letter to Bryce L. Shriver, "Request for Additional Information (RAI) – Susquehanna Steam Electric Station, Units 1 and 2 (SSES 1 and 2) – Power Range Neutron Monitor System Digital Upgrade (TAC Nos. MC7486 and MC7487)," dated February 9, 2006.*

3) *PLA-5983, B. T. McKinney (PPL) to Document Control Desk (USNRC) "Susquehanna Steam Electric Station Proposed License Amendment Numbers 272 for Unit 1 Operating License No. NPF-14 and 241 for Unit 2 Operating License No. NPF-22 Power Range Neutron Monitor System Digital Upgrade Supplemental Information," dated December 1, 2005*

The purpose of this letter is to supplement the proposed amendment request, which requested a license amendment to the Susquehanna Steam Electric Station (SSES) Unit 1 and Unit 2 Technical Specifications to implement a digital upgrade to the Power Range Neutron Monitor System (Reference 1). The supplemental information provided herein documents the information requested by NRC in a letter dated February 9, 2006 (Reference 2). Teleconferences were held between NRC and PPL Susquehanna, LLC (PPL) on February 1, 2006 and on February 15, 2006. Communication with NRC clarified the level of

A001

detail requested by NRC in the PPL responses. The supplemental information is in accordance with the NRC clarifications and is provided in the Attachment.

Previous supplemental information, requested during a teleconference on November 2, 2005, was provided in Reference 3.

PPL has reviewed the No Significant Hazards Consideration and the Environmental Consideration submitted with Reference 1 relative to this supplemental information. We have determined that there are no changes required to either of these documents.

PPL respectfully requests that NRC expeditiously complete the review and approval of the proposed Power Range Neutron Monitor Digital Upgrade License Amendment Request, which was originally requested in Reference 1 to be by February 1, 2006. PPL continues to plan to install the digital PRNMS upgrade in the Spring 2006 Outage.

If you have any questions or require additional information, please contact Mr. John Oddo at (610) 774-7596.

I declare under penalty of perjury that the foregoing is true and correct.

Executed on: 2/28/06

for B. T. McKinney

Attachments:
Attachment 1 - Supplemental Information

cc: NRC Region I
Mr. A. J. Blamey, NRC Sr. Resident Inspector
Mr. R. V. Guzman, NRC Project Manager
Mr. R. Janati, DEP/BRP

Attachment 1 to PLA-6012

Supplemental Information

**SUBJECT: PROPOSED LICENSE AMENDMENT REQUEST
POWER RANGE NEUTRON MONITOR SYSTEM
DIGITAL UPGRADE**

The supplemental information provided herein documents the information requested by NRC in a letter dated February 9, 2006. Teleconferences were held between NRC and PPL Susquehanna, LLC (PPL) on February 1, 2006 and on February 15, 2006. Communication with NRC clarified the level of detail requested by NRC in the PPL responses. The supplemental information is in accordance with the NRC clarifications and is provided in this Attachment.

NRC QUESTION 1:

Provide the analysis or reference document that links the configuration of the original system designed, tested, and described in the NRC approved GE Licensing Topical Report (LTR) NEDC-32410P-A, "Nuclear Measurement Analysis and Control Power Range Neutron Monitor (NUMAC PRNM) Retrofit Plus Option III Stability Trip Function," and its Supplement 1, to the configuration of the systems which will be installed at SSES 1 and 2. This analysis should include any changes to the hardware, software, or processes used to fabricate the system and the justifications that these changes do not effect the SSES 1 and 2 system capability to meet the original protection system design requirements. For the software-related, process portion of this analysis, the staff plans to focus on any changes, to the following documents, identified in Branch Technical Position (BTP) Instrumentation and Controls Branch (HICB)-14, "Guidance on Software Reviews for Digital Computer-Based Instrumentation and Control Systems":

Software Management Plan
Design Specifications
Software Development Plan
Software Quality Assurance Plan
Software Configuration Management Plan
Software Safety Plan
Design Safety Analysis
Software V&V Plan
V&V Change Report
Configuration Management Change Report

Section 2, "Information to be Reviewed," of BTP HICB-14-7, explains that: "the applicant/licensee need not develop a separate document for each of the topics identified below; however, project documentation should encompass all of the topics." As a consideration for staff review, since the actual documents will not be submitted, please identify the procedure where the topic is found if a procedure, listed above, was not specifically generated.

PPL Response:

The SSES plant-specific aspects or differences between the SSES-specific NUMAC PRNM system and the system described in the GE LTRs NEDC 32410P-A and NEDC 32410P-A, Supplement 1, including both functional differences and equipment differences as described in the LTRs, are described in the PPL submittal, PLA-5880. The original PRNM equipment design and any subsequent changes thereto, for either generic application or SSES-specific application, were performed in accordance with issued, corporate numbered and controlled software development plans, the latest NRC-reviewed and approved GE and/or PPL quality system, as committed by GE during the original review (ref. NRC SER Section 3.2 included in NEDC 32410P-A). The differences between the SSES-specific NUMAC PRNM system and the system described in the GE LTRs NEDC 32410P-A and NEDC 32410P-A, Supplement 1 do not affect the SSES 1 and 2 system capability to meet the original protection system design requirements.

Any changes to software required either due to equipment changes, problem resolution, or SSES-specific requirements underwent the same level of software V&V as the original design. Records and reports documenting software V&V actions, both generic and SSES-specific, are documented in GE QA records in accordance with the issued software design plans and the GE QA program. A more specific discussion of the software changes since the original PRNM design and the design process applied for SSES in relation to the BTP HICB-14 items is included below.

The original PRNM design was qualified in accordance with the commitments included in the GE LTR NEDC 32410P-A and reviewed and accepted by the NRC as part of the LTR review. Qualification of SSES-specific equipment, either by showing applicability of the original qualification or by supplemental qualification actions, is evaluated and documented in an SSES-specific Qualification Summary Report, filed in the GE design records and provided to PPL as a project deliverable. This is consistent with other plants implementing the NUMAC PRNMS. The Qualification Summary Report includes a specific evaluation of equipment differences between the SSES-specific equipment and the originally designed and qualified equipment.

Adequacy of the separation and independence of channels of the SSES-specific implementation, including all plant interfaces, is evaluated specifically for compliance with plant-specific separation requirements, including both the equipment aspects specifically discussed in the NUMAC PRNM LTRs and any plant-specific aspects of the implemented systems. The separation evaluation and conclusions are documented in an SSES-

specific PRNM Separation Analysis, which is filed in the GE design records and provided to PPL as a project deliverable. This is consistent with other plants implementing the NUMAC PRNMS.

Software

Changes to design aspects are consistent with the GE commitments during the original NRC review of the PRNM LTRs and documented in the NRC SER included in the GE LTR NEDC 32410P-A; all such changes have undergone V&V actions fully consistent with those applied to the original design. Appendix A provides a list of APRM/OPRM functional software changes by module numbers, description and file date. For SSES 1 PRNM, the software V&V process was applied and full V&V test was performed to SSES requirements.

Appendix B, NUMAC APRM Firmware Development Process Synopsis, describes how the software is developed for a particular application. The software design starts from the latest (preceding application) firmware stored in the archived library account. This is possible, as the software has been maintained to be "backward" compatible with previous PRNM projects. The NUMAC plans require that the firmware source and build files be placed in the NUMAC library. Only the Responsible Configuration Control Engineer (RCCE), who has no software design responsibility, has "write" privileges for the library account. Thus a newer version or an unapproved version cannot be replaced.

Hardware

A list of major subcomponents, including their respective part number and revision number (e.g., CPU board, memory boards, power supply, display unit etc.), is provided in Appendix C herein. Major subcomponents are those typically maintained as a spare part by the utility.

All hardware interface or detailed hardware differences between the SSES-specific PRNM equipment and the original generic equipment, either to implement SSES-specific requirements or to replace obsolete components are accomplished and documented in accordance with the NRC-approved GE design control and design change control program, including design verification against SSES-specific and generic PRNM requirements. The process for determining and accepting how a subcomponent change is analyzed to be acceptable in terms of form, fit and function is documented in the GE design control program (EOP 55-2.00 and EOP 55-10, revision dates as applied to the projects).

PPL has been requested to "identify what significant changes to the hardware have been made, if any, to the original system and the justification that this change did or did not change the form, fit, and function with the determination that the original protection system requirements are satisfied." Function refers to the function of the module not the function of the system. The criterion for determining significant changes is any modification that would require a change to the schematic drawings of the circuitry, or any physical change which could affect the seismic or environmental qualification of the system. Based on this criterion and the information in Appendix C, PPL has determined that one memory module, the GEDAC Communication Memory Module (228B2722G005) module falls within the definition of "significant change."

The change to the GEDAC Communication Memory Module consisted of replacing the originally used GEDAC Optical Electrical Interface Board (228B2720G004) with GEDAC Optical Electrical Interface Board (148C7608G001). The Optical Electrical Interface Board is a daughter-board installed on the GEDAC RAM Communication Motherboard (228B2714G003) that was used in the original design. The new Optical Electrical Interface Board eliminated an unused RS-232 electrical output, added three fiber-optic outputs, and changed the fiber-optic connectors to an industry standard type. With the exception of the circuit schematic diagram, there were no changes that required a change to the system firmware or any physical change that affected the seismic or environmental qualification of the system. The changes to the schematic diagram reflect the interfaces to the new Optical Electrical Interface Board and applicable reference document numbers.

Qualification of SSES-specific equipment, either by showing applicability of the original qualification or by supplemental qualification actions, is evaluated and documented in an SSES-specific Qualification Summary Report, filed in the GE design records and provided to PPL as a project deliverable. Evaluation conclusions found that the environmental and EMC qualification levels for the SSES PRNM equipment identified were qualified for the application.

Software Design Process & Process Changes

The primary US NRC guideline available at the time the NUMAC design processes were developed was US NRC Reg. Guide 1.152 – 1985, primarily endorsing ANSI/IEEE 7-4.3.2 – 1982. IEEE 7-4.3.2 – 1993 was issued prior to completion of the original PRNM design, but was not endorsed by the US NRC until 1996 (via RG 1.152 – 1996). Evaluation of the NUMAC design process against both of those guides is included in

NEDC 32410P-A, Appendix A. In addition, NEDC 32410P-A, Supplement 1, Appendix A, includes an evaluation of the process ANSI NQA2, Part 2.7. A general description of the design process applied to the NUMAC PRNM is included in NEDC 32410P-A, Chapter 9. Finally, Appendix C in NEDC 32410P-A includes a comparison of the NUMAC PRNM equipment with NUMAC equipment previously designed and reviewed by the US NRC.

The NUMAC PRNM software design process is documented in three GE corporate numbered plans:

- NUMAC Software Configuration Management Plan
- NUMAC Software Management Plan
- NUMAC Software Verification and Validation Plan

Except for the NUMAC Software Management Plan, these plans are unchanged from the time of the original NRC review of the PRNM LTRs (1995). In 2000, previously issued outstanding changes to the NUMAC Software Management Plan were incorporated (Revision 2). The first outstanding change, issued in 1998, added a requirement that the Product Performance Specifications shall include identification of hardware adjustments requirements. This change is unrelated to software functions, but was included in the Plan because the Plan identifies NUMAC specification requirements. In the NUMAC design process, the Product Performance Specification includes full requirements for the item whether the function is software controlled or hardware controlled. The second outstanding change also issued in 1998, updated references to RG 1.152, rev 1, and IEEE Std 7.4.3.2 – 1993 were added in the NUMAC Software Management Plan after review confirmed that the plan complied with these later revisions.

Since the original PRNM design and NRC review of the NUMAC PRNM LTRs, the NRC has issued BTP HICP-14. This BTP and most of the US NRC Regulatory Guides listed therein were not issued at the time of the original design of the NUMAC PRNM equipment. The PRNM scope is limited to one sensor system within the Reactor Trip System, and is designed by hardware means to fail-safe (tripped).

The NUMAC PRNM design process satisfies the criteria that were in place at the time of the design and includes basic process steps consistent with recommendations in this BTP.

Appendix D correlates specific software design process documents identified in the BTP with the corresponding or equivalent documents used in the NUMAC PRNM design process.

NRC QUESTION 2:

In Section 3.3, "Plant Process Computer Impact" PPL discusses the data transmission to be: "through a serial fiber-optic link to the new Multi-Vendor Data (acquisition system) (MVD) interface unit." Essentially, the data transmission path has changed from going through hardwire and the Oscillation Power Range Monitor (OPRM) module, to all process data going through the MVD module. The MVD will, in turn, transfer the information on an Ethernet bus to the plant process computer. Similarly, plant computer-calculated Local Power Range Monitor (LPRM) gain values and calculated core thermal power (to be used by the Average Power Range Monitor (APRM) to adjust the APRM gains) are transmitted via the Ethernet bus to the MVD, and onto the PRNMS. The NRC staff requests the following with regards to how the data is used and the transmission method involved:

A. Explain the extent of the operator involvement in the generation, review and use of these new LPRM gain and calculated core thermal power values, which can effect APRM and OPRM setpoints.

B. Show how this communication provision (the two way communications path between the PRNMS system and the plant computer) through the MVD, is consistent with safety system-to-non-safety system separation and the isolation requirements of Institute of Electrical and Electronics Engineers-279 in terms of the data transmission, cyber security, and electrical isolation.

PPL Response:

2A. Operator Involvement

The process to generate LPRM gain and core thermal power values is unchanged from the currently established process. The use of these values for updating the calibration and adjustment of the PRNM equipment is changed from a fully manual process to a semi-automatic process.

In the current process, a trained technician, under procedural control, makes physical adjustments (potentiometer adjustments) in the PRNM equipment with meter readouts to implement LPRM and APRM gain adjustments based on data sheets provided by the plant computer followed by a procedurally controlled verification process to assure that the adjustments have been correctly implemented.

With the replacement system, a trained technician still receives a data sheet of LPRM adjustment values, but uses that sheet for verification review only. The technician, under procedural control and after security access, selects the "update" screen and confirms that the latest values have been downloaded. The equipment calculates and displays (but does not use) the adjustments and/or new values that will result from the downloaded data. The technician reviews the "pending" values based on the plant computer data sheets. If the downloaded values shown on the equipment displays agree with the values from the data sheets, the pending values are accepted, by specific technician action, for use by the equipment. This final step is equivalent to the mechanical adjustment of the gain values in the current system.

For the APRM adjustment, the process is similar except that the Operators perform the adjustment based on computer displays.

It should be noted that each of the individual gains can be adjusted locally without the automatic download feature.

The process is unchanged in that it still requires a manual action to both initiate the process and accept and implement the results.

2B. Isolation and security

GE LTR NEDC-32410P-A, sections 5.3.2.7 & 5.3.5.1, include a discussion of the electrical and data interface isolation methods used, with the understanding that the SSES "MVD" is the interface to the "plant computer." The data path from the plant computer, via the MVD, to the APRM is over fiber-optic links from the MVD to the RBM, and from the RBM to the APRM, which provide the electrical isolation between the MVD and the APRM.

As further discussed in section 5.3.5.1, the APRM hardware includes data buffering and logic to provide "information isolation" to assure that no signals from the external systems can affect the APRM safety functions. Although not specifically discussed in section 5.3.5.1, the RBM interface to the MVD also includes similar information isolation to assure that no signals from the MVD can cause adverse operational impact on the RBM. With the clarification that the MVD is the "plant computer" for SSES for purposes of the discussion in section 5.3.5.1, the discussion fully applies to the SSES-specific PRNM system.

The following non-safety information is sent to APRM via RBM:

- LPRM/APRM gain downloads and CTP,

- o LPRM I/V requests, and
- o time-of-day for time stamping the I/V data.

The LPRM/APRM gain downloads and CTP are manually initiated communications utilized for instrument calibration, as discussed above under 2A. The LPRM I/V requests are manually initiated functions that provide an operator (technician) aid for determining in-core detector sensitivity. The time-of-day stamping accompanies the I/V data.

The bi-directional Fiber Direct Data Interface (FDDI) Modules, NEDC-34210P-A section 5.3.3.9 are used to transfer messages from the RBM to the APRM by continually transferring a block of RAM data from the RBM's FDDI Module to the APRM's FDDI Module, a path different than the CPU memory path. Interrupts are not employed to receive new messages. Instead, each message type is examined to see if a new message has arrived. A message is determined to be new by examining a count value contained in the message that is incremented each time the RBM sends a new message. The CPU fetches the data only when the count changes. The data can only move under CPU control. Therefore, the data cannot propagate beyond the display status.

GE LTR NEDC-32410P-A, section 5.3.6, provides discussion of data validation prior to its use in the NUMAC PRNM system. (This would include data such as Gain Adjustment Factors, Percent Core Thermal Power, LPRM detector signals, and recirculation flow loop differential pressure signals.) The 3rd bullet is the administrative action discussed in the response to RAI 2A. The 4th bullet applies to both the RBM/APRM and RBM/MVD communications. The discussion in section 5.3.6 fully applies to the PRNM system for SSES.

GE LTR NEDC-32410P-A, section 6.4.3.2.1, provides a discussion of the design approaches to mitigate consequences. This section provides a list of approaches that can significantly reduce the risk of an unacceptable consequence of a common cause design problem and allow the individual channels to recover independently. As discussed in that section, a software watchdog timer is employed that will result in an APRM reset and trip if any safety-related task is observed to take more than the allotted time and a hardware watchdog timer will cause an APRM reset and trip if the software watchdog timer is not operating properly. Therefore, it meets the intended fail safe safety function of the PRNMS system.

GE LTR NEDC-32410P-A, section 5.3.13, provides a more specific discussion of the security methods that apply to the APRM and LPRM gain adjustments as discussed in the response to RAI 2A. The PRNMS has three levels of security. The first level requires a password only. The second

level is implemented by the use of a keylock switch on each APRM and RBM to provide Operate and INOP mode switching. The third level is implemented by requiring a correctly entered password after switching modes with the keylock switch. The discussion in section 5.3.13 expands upon these security levels which fully apply to SSES-specific PRNM system.

There are no data-link connections to outside systems from the PRNM except via the MVD and plant computer. The design aspects of the interface between the APRM channel and the MVD (via an RBM) assures that no faulty information from the plant computer can spontaneously change any APRM (or RBM) settings or values, regardless of whether the information comes from normal plant computer operations, a malfunctioning plant computer, or some outside source via the plant computer.

APPENDIX A

NUMAC APRM/OPRM Firmware Changes

The table below identifies changes made to the safety-related APRM/OPRM firmware since the original design. The table lists the files containing revised firmware and a description of the change(s). This table does not include changes made to the data files that are changed for each new plant application.

File	Description of Change	File Date
ANALYZER.C	04/15/99 - Added compile-time enhancement Save_IV_Abort_Data in procedure abort_analyzer to save previous analyzer data on an abort condition. 11/08/99 - Revised procedure permit_auto_bypass to restrict condition under which IV plotting is allowed. Corrects a reported problem.	8-Nov-1999
ASP_STAB.C	09/07/05 Started with the Detect and Suppress Solution - Confirmation Density (DSS-CD) version of the OPRM firmware installed at other plants. 1. Main – Revised procedure to execute at 46.08 ms (was 23.04 ms). 2. Initialize, Set_oprm_outputs, and Perform_stability_calc – Revised procedures by removing firmware related to ABA and GRBA alarms. 3. Perform_stability_calc – Revised procedure to require a peak-to-valley difference of 0.0004 or greater for slope change detection. 4. Calc_confirm_period – Revised procedure to use the average time of the confirming periods (was the previous period's time).	23-Jan-2006
ASP.PLM	05/12/98 - Revised procedure read_asp_cal_output to prevent against the possibility of a false refresh error. Corrects a reported problem. 07/20/98 - Revised procedure set_asp_cal_output to ramp the CAL voltage from last voltage setting to the new voltage setting in 120mV steps in order to be compatible with the Cal/Monitoring panel. Corrects a reported problem.	21-Jul-1998
BROADCAST.C	06/18/95 - Revised the bcr_xmit_diag data structure and the check_bcr_xmit_stst and test_last_rx procedures to enhance the capability to detect an intermittent fiber connection. Corrects a reported problem. 03/23/05 - Revised test_last_rx function to suppress an error if invalid or no data is received from a non-home APRM channel that is bypassed. Corrects a reported problem.	23-Mar-2005

APPENDIX A

File	Description of Change	File Date
CALIBRATE.PLM	02/24/97 - Revised the procedure Calc_Expected_Resp to use ASP offset in 16-bit counts to improve accuracy of data collected to better detect D/A and A/D errors. Corrects a reported problem. 02/28/97 - Revised procedure Do_Cal_Voltage_Check to apply the A/D offset and gain corrections to the Analog I/O module since the input_analog routine does not apply the calculated calibration corrections. Corrects a reported problem. 07/23/97 - Revised procedures Calc_Cal_Gains, Calc_Cal_Offsets, Calc_Calchk_Points, and Calc_Cal_Path_Ratio to reset CAL output voltage to 0V before configuring the LPRM's CAL mode and CHAN mode in order to be compatible with the Cal/Monitoring panel. Corrects a reported problem. 08/10/01 - Corrected improper values of the Flow "Calibration Constant" from being displayed. Corrects a reported problem. 03/22/05 - Revised procedure initialize_cal to correct for a possible watchdog timeout while entering the calibrate frequency check function. Corrects a reported problem.	19-Sep-2005
CHASSIS.PLM	05/30/97 - Added support for Broadcaster output/relay check. 07/22/97 - Modified procedure Process_Calcheck. Now resets the CAL output to 0V before switching the CAL checkpoints. 03/22/05 - Revised procedure reset_task_time_log to correct for a possible watchdog timeout while entering the calibrate frequency check function. Corrects a reported problem.	19-Sep-2005
CPU.PLM	11/12/98 - Removed upper bank NVRAM store on Watchdog Timeout since it is only needed to store diagnostics on a timeout. This prevents a possible false NVRAM initialization error (NUMAC-AP NVRAM write error. Corrects a reported problem.	30-Nov-1998
DSPIN.C	07/14/98 - Added "1-out-of-4" mode in Trip Check.	14-Jul-1998
DSPOUT.C	06/24/98 - Added compile-time enhancement Dual_Slope_Enabled for dual slope operation. 04/15/99 - Added compile-time enhancement Save_IV_Abort_Data to save previous analyzer data on an abort condition. 06/29/02 - In send_parameter_msgs changed decision to send F12 based on compile-time enhancement Oprm_Enabled and not plant type. 06/29/02 - Changed decision to include F12 in format_msg to be based on compile-time enhancement Oprm_Enabled and not plant type. 06/29/02 - Added non-OPRM definition to Param_msg_list. 06/29/02 - Redefined Aprm_tx_list and Aprm_tx_sens_list from plant type to compile-time enhancement Oprm_Enabled. 10/27/05 - Revised formatting of displayed OPRM data to accommodate increased resolution.	27-Oct-2005

APPENDIX A

File	Description of Change	File Date
FDDI_API.C	05/07/97 - Revised to send "rel_amp" instead of "amp_peak" value for cell data. Corrects a reported problem. 09/02/97 - Corrected calculation of LPRM downscale reset point in the AL3 message to correct an alarm setpoint hysteresis problem. Corrects a reported problem. 06/24/98 - Added compile-time enhancement Dual_Slope_Enabled for dual slope operation. 04/29/99 - Corrected problem with LPRM GAF downloads. Corrects a reported problem. 10/27/05 - Removed GRBA and ABA Alarm setpoint from message sent to RBM when Susquehanna plant flag is True.	27-Oct-2005
FLOW.C	08/25/97 - Corrected problem with flow cal check process using the user entered current input gain & offset. 06/24/98 - Added compile-time enhancement Dual_Slope_Enabled for dual slope operation. 08/06/02 - Corrected Flow Cal Check interaction problem. Corrects a reported problem. 09/02/05 - Added compile-time enhancement Allow_Neg_flow to ignore the lower clamp for flow biased setpoints in single loop operation per Susquehanna requirement.	02-Sep-2005
IO.C	06/28/02 - Added analog output exception for Nuclenor. 04/20/05 - Added compile-time enhancement Rrcs_Ps_Fault. 09/12/05 - Added analog output configuration for Susquehanna.	12-Sep-2005
MTEST.PLM	10/01/97 - Corrected problem with ODIO Relay Output tests. 11/12/98 - In procedure test_cpu, removed checksum test on OPRM parameters and OPRM cell assignments if the unit is not an APRM master unit. 07/09/02 - Added plant specific mask for Nuclenor to prevent unwanted Downscale, SRI, and Stability 2/4 Module faults. 03/23/05 - Added generic mask to prevent unwanted Downscale, SRI 2/4 Module faults.	19-Sep-2005
OPRM.C	11/08/04 - Initialization firmware for the Stability module was modified to only enable the A18 Module interrupt if the APRM was the master unit. 09/06/05 - GRBA and ABA alarms are not checked per Susquehanna requirement.	19-Sep-2005

APPENDIX A

File	Description of Change	File Date
POWER.C	03/17/97 - Corrected an error in AGAF calculation for large plant configurations. Corrects a reported problem. 07/05/01 - Added compile-time enhancement Oprm_With_Inop_Enabled to procedure build_bcr_tripword to set the OPRM trip output from the broadcaster whenever an APRM Instrument Inoperative condition exists. Corrects a reported problem. 06/26/02 - Added a definition for Aprm_alarm.rod_block as OPRM variables are not defined when compile-time enhancement Oprm_Enabled is false. 06/26/02 - For Nuclenor, the previous STP trip is now based on APRM Flux. STP alarm remains based on STP. 03/23/05 - Added a display_alarm byte that controls the alarm indication in the display header. 04/20/05 - Added compile-time enhancement Rrcs_Ps_Fault.	20-Apr-2005
SERIAL.PLM	06/28/02 - Procedure send_dsp_msg was revised to not send a message if the message length was 0.	28-Jun-2002
SETPARAMS.C	04/29/98 - Added default LPRM initialization in procedure assign_default_oprm_cell to prevent a possible false NVRAM initialization error. Corrects a reported problem. 04/29/98 – In the procedure Save_nvram_eprom, removed checksum verification for OPRM parameters and OPRM cell assignments if unit is not an APRM unit or the ORPM is not enabled to prevent a possible false NVRAM initialization error. Corrects a reported problem. 04/29/98 - Removed checksum of TOPPS parameters if unit is not configured for KKM to prevent a possible false NVRAM initialization error. Corrects a reported problem. 06/24/98 - Added compile-time enhancement Dual_Slope_Enabled for dual slope operation. Allows independent slope adjustments. 06/26/02 - Prevented assign_default_oprm_cell from accessing variables not accessible when OPRM is not enabled.	05-Jan-2006
STAB_ASP.C	10/27/05 - Removed processing the GRBA and ABA alarm cell status per Susquehanna requirement.	27-Oct-2005

APPENDIX B

NUMAC APRM Firmware Development Process Synopsis

Design Inputs

When APRM firmware is developed for a particular PRNM system application, the Performance Specification is the major input to the design and is used with other referenced Product Performance Definition documents (see LTR NEDC-32410P-A, Sec. 9.2.3).

The firmware is developed using the base APRM Performance Specification and the applicable APRM Performance Specification Data Sheet. The base performance specification describes the "generic" APRM performance characteristics, while the data sheet provides additional design input and further describes exceptions and differences between the base APRM application and the new application. From these documents a base APRM Functional Controller Software Design Specification and the applicable APRM Functional Software Design Specification data sheet are provided.

In most cases, the differences described by these input documents only involve changes to database files. However, if a data sheet requires that a new enhancement be developed, the new firmware will be added and maintained as described below.

Firmware Control

The APRM firmware is developed, maintained, and controlled per the NUMAC Software Configuration Management Plan (CMP). Per the CMP, revision control is maintained on an instrument, project, and firmware release basis. As an example, the safety-related firmware for the Susquehanna APRM firmware has been stored in a VAX library directory named NUMACAPRM.FUNCODE.SUSQ.REV0.

After firmware has been validated and is about to be unconditionally released to production inside GE, the NUMAC plans require that the firmware source and build files be placed in the VAX library directory. The Responsible Configuration Control Engineer (RCCE) is directed to move these files along with a Firmware Release Description (FRD) to the appropriate library directory. Only the RCCE has "write" privileges for the VAX library for this instrument family. The RCCE has no software design responsibility, and reports to a manager other than the manager with software design responsibility. Once archived, the FRD is checked by independent review to assure that the document correctly describes the process used to rebuild identical EPROMs (checksums). To perform this review, the files are copied from the library directory, a temporary non-controlled directory and then rebuilt. The FRD will become part of the baseline process and the checksums will be used to link the files with the EPROM checksums recorded during the Verification and Validation testing.

APPENDIX B

Once the software modules have been stored in the unique VAX library directory for the plant application (and revision), and have been independently reviewed to be the correct files, there is no longer a need to revise, modify, or alter in any manner the archived firmware in this directory. Furthermore, only the RCCE has knowledge of the library password. This process prevents a controlled software module from being replaced with a newer, but unapproved version.

When the next APRM project commences, the software design engineers will start from the latest APRM firmware that is stored in the library directory and confirm that the correct set of modules has been retrieved by checking that the checksum matches that maintained in the project's FRD. For the recent Susquehanna project, the firmware from the VAX directory NUMACAPRM.FUNCODE.CHINSHAN.REV0 directory was used. This is possible as the software is maintained to allow use for both new and prior APRM projects.

Firmware History

Compatibility is accomplished by the use of compile-time directives in the form of "Project" and "Function Enhancement" flags. These flags are maintained in the various firmware files, i.e., the 'source' and the 'include' files. For example, when KKM (the first in the lineage of PRNMs) was developed, a plant compiler directive for "Plant_KKM" was made. All plant specific configuration details (LPRMs per channel, LPRM levels per input, analog outputs, user parameters ranges, etc) were specified in the files to be included only if the "Plant_KKM" flag was set to True.

As newer projects were designed, additional compile-time directives were added for these projects. Since the initial KKM project, the project lineage has included plant directives for the following; Hatch 1 & 2, Browns Ferry 2 & 3, Nine Mile Point 2, Fermi 2, Peach Bottom 2 & 3, Limerick 1 & 2, Brunswick 1 & 2, Nuclenor, Laguna Verde 1 & 2, and Chinshan 1 & 2.

Another type of firmware change that may occur is related to new functions that have been added. These have also been designated using compiler directives, called compile-time enhancements. For example, a new function added to Susquehanna was to change the way in which the flow-biased setpoint values are calculated when single loop operation is enabled. So, there now exists a new compile-time enhancement flag that allows future and prior applications to use either method of calculating the flow-biased setpoint values. Other examples of new functions are Dual Slope Capability, RRCS Trip, and Negative Analog Outputs.

A final type of firmware change that may occur is in response to a reported firmware problem. These are documented in problem reports for problems that have been discovered and/or received from various sources. These sources could be from a problem experienced at an operating plant, or there could be other possible origins. Typically, the

decision to include the correction for a problem is made at the Definition and Planning phase since the plant licensing and operation personnel is made aware of the change and has an opportunity to evaluate the need. In some cases, correcting a problem could result in an adverse effect on plant documentation, training, and the plant may choose to not incorporate a specific problem correction.

Firmware Testing

Once revised, changes to the firmware (i.e., the database and source files) are tested, at various stages, in accordance with the Software Management Plan (SMP). The Verification and Validation Plan (VVP) is used to develop and control the final V&V test. The intent of the V&V test is to test to ensure that all (not just the revised firmware - although additional test emphasis may be placed on revised firmware) is tested. A V&V test typically takes two to three weeks to complete and is performed on the complete system using equipment that simulates all system inputs as well as monitors all system outputs.

Once the firmware testing process has been completed, the revised software is archived per the CMP and becomes an integral part of the Validation and Software Issue. This provides application configuration management, without question, of the files that are in use at any specific plant.

Future Application

If an existing plant requests a new function or firmware the designer would not start with the latest revision for that project. Instead, the designer would start with the files that are in the latest library directory. At this time, that would be the Susquehanna Revision 0 library directory. The designer would first rebuild the firmware in a temporary directory and confirm that the checksums agree with that contained in the FRD. The designer would then proceed to change the compiler directives and flag, add or change the function compiler directives, and build the new set of firmware. If required by the applicable specification data sheets, a new function along with a corresponding compiler directive would be added. In addition, any unincorporated problem correction, as called out in the Project Plan and thus approved by the utility to incorporate, would also be included. After the various stages of testing, that firmware would be stored by the RCCE, using the CMP process, in a new library for that plant, but with that plant next library revision number.

Summary

The PRNMS firmware is developed, maintained, and controlled per the NUMAC Configuration Management Plan.

APPENDIX B

In order to maintain software module integrity and fidelity, a uniquely named VAX directory is created for each project revision to store the complete set of required software modules.

Once established and independently verified, these directories are no longer modified, as a later revisions of the firmware will be stored in their own unique VAX directory.

The most recent applicable project is the starting point for the next project. Compile-time directives and plant flags are used to control database and applicable enhancements.

APPENDIX C

NUMAC Hardware Module Change Summary

Table C summarizes the changes to the modules used in the Susquehanna PRNM System since the initial U.S. application at Plant Hatch in 1997.

With the exception of the GEDAC Communication Memory Module (228B2722G005), all changes to the hardware post-Hatch are fully interchangeable with respect to form, fit and function in accordance with GE Nuclear Engineering Operating Procedure 55-10.00. Again, with the exception, the Susquehanna part numbers are identical to those used during the initial application at Plant Hatch in 1997. There were no significant changes that required a change to the circuit schematic diagrams, system firmware or any physical change that affected the seismic or environmental qualification of the system.

The change to the GEDAC Communication Memory Module consisted of replacing the originally used GEDAC Optical Electrical Interface Board (228B2720G004) with GEDAC Optical Electrical Interface Board (148C7608G001). The Optical Electrical Interface Board is a daughter-board installed on the GEDAC RAM Communication Motherboard (228B2714G003) that was used in the original design. The new Optical Electrical Interface Board eliminated an unused RS-232 electrical output, added three fiber-optic outputs, and changed the fiber-optic connectors to an industry standard type. With the exception of the circuit schematic diagram, there were no significant changes that required a change to the system firmware or any physical change that affected the seismic or environmental qualification of the system. The changes to the schematic diagram reflect the interfaces to the new Optical Electrical Interface Board and applicable reference document numbers.

APPENDIX C

Module	Susquehanna Part Number	Parts List Rev	Date	Description
Front Panel	112D5122G001	11	2/4/05	Change Electro-Luminescent display Item 4 and add alternate item 4 to G005. Apply to in-process and future.
Front Panel	112D5122G001	10	1/6/03	Add G6. Apply to in-process and future.
Front Panel	112D5122G001	9	4/29/99	Add alternate terminal lug item 030 to G001-G005. Apply to in-process and future.
Front Panel	112D5122G001	8	3/26/99	Add G005. Change G004 Front Panel item 003 part #. G001, G003 delete EL Display Assembly alternate item 004. Apply to in-process and future.
Front Panel	112D5122G001	7	12/9/98	Change cover sheet group description. G001, G003 add alternate Assembly item 004. Add new G004. Apply to in-process and future.
Front Panel	112D5122G001	6	8/8/97	PL document change to delete item 19 - not used. Apply In-process and future.
Front Panel	112D5122G001	5	5/27/97	Add G003.
Front Panel	112D5122G001	4	4/24/97	Document change to correct item 016 part # to agree with EMPIS format.
Broadcaster Module	148C6413G004	3	8/1/03	Add test procedure item 102 to G002 and G004. Apply to in-process and future.
Broadcaster Module	148C6413G004	3	12/7/05	Change resistor item 403 part # for G004. Apply to in-process.
Broadcaster Module	148C6413G004	2	10/8/98	Changed cover sheet description, added G003 and G004. Updated shipped plants by Field Disposition Instruction (FDI). Apply to in-process and future.
DC-DC Converter	148C6776G001	2	---	No changes post-Hatch.
Relay Logic Card	148C6797G001	3	8/15/05	Add G002.
2/4 Logic Card	148C6803G001	7	3/23/05	Add alternate PLD item 210 and 211 to G001 and G002. Apply to in-process and future.
2/4 Logic Card	148C6803G001	6	8/24/00	Add alternate Peripheral Latch IC item 202 to G001-G002. Apply in-process and future.
2/4 Logic Card	148C6803G001	6	7/10/01	Add alternate diode array item 301 to G001-G002. Apply to in-process and future.
2/4 Logic Card	148C6803G001	5	4/11/00	Add G002.
2/4 Logic Card	148C6803G001	4	9/19/97	PL document change - change item 605 quantity to match actual quantity used. Apply in-process and future.
FDDI Comm Module	178B3754G001	5	4/25/03	Add alternate NVRAM item 208 to G001. Apply to in-process and future.
FDDI Comm Module	178B3754G001	4	7/7/00	Add alternate CMOS IC item 203 to G001. Apply to in-process and future.

APPENDIX C

Module	Susquehanna Part Number	Parts List Rev	Date	Description
LPRM Module	178B3763G001	9	5/17/04	Add alternate OP AMP item 204 to G001. Apply to in-process and future.
LPRM Module	178B3763G001	8	10/7/02	Add alternate Peripheral Latch IC item 207 to G001. Apply to in-process and future.
LPRM Module	178B3763G001	8	10/9/02	Correct the Change Description of RMCN01258 Rev 0.
LPRM Module	178B3763G001	7	5/24/02	Add alternate resistors item 401 and 404 to G001. Apply to in-process and future.
LPRM Module	178B3763G001	6	3/26/02	Delete alternate resistor item 402 from G002. Apply to in-process and future.
LPRM Module	178B3763G001	5	1/18/02	Add alternate resistor item 402 to G001-G002. Apply to in-process and future.
LPRM Module	178B3763G001	4	11/5/01	Delete G002. Change solid state relay part 3 item 301 for G001. Apply to in-process and future.
LPRM Module	178B3763G001	3	10/19/01	Add G002.
ASP Module	178B3765G001	12	5/17/04	Add alternate OP AMP item 215 to G001. Apply to in-process and future.
ASP Module	178B3765G001	11	5/24/02	Add alternate resistors item 403-406 and 415 to G001. Apply to in-process and future.
ASP Module	178B3765G001	10	1/18/02	Add alternate resistors item 405 to G001. Apply to in-process and future.
ASP Module	178B3765G001	9	7/11/00	Change alternate item 210 PLD Adapter Card to G001. Apply to in-process and future.
ASP Module	178B3765G001	8	7/6/00	Add alternate PLD item 210 to G001. Apply to in-process and future.
ASP Module	178B3765G001	7	5/21/99	Correct item 705 quantity.
ASP Module	178B3765G001	6	10/13/98	Add alternate 16-bit converter IC item 205 to G001. Apply to in-process and future.
386SX Memory Card	178B3767G002	5	4/25/03	Add alternate SRAM IC item 203 to G001 and G002. Apply to in-process and future.
386SX Memory Card	178B3767G002	4	1/19/98	Add alternate Marker item 800 to G001 and G002. Apply to in-process and future.
386SX Processor Card	178B3769G002	8	7/11/00	Change alternate item 211 PLD Adapter Card to G001-G002. Apply to in-process and future.
386SX Processor Card	178B3769G002	7	7/6/00	Add alternate PLD item 211 to G001-G002. Apply to in-process and future.
386SX Processor Card	178B3769G002	6	3/29/00	Add alternate 8274 IC item 206 to G001 and G002. Apply to in-process and future.

APPENDIX C

Module	Susquehanna Part Number	Parts List Rev	Date	Description
386SX Processor Card	178B3769G002	5	12/10/98	Add alternate microprocessor adapter module item 207 to G001 and G002. Apply to in-process and future.
386SX Processor Card	178B3769G002	5	7/6/99	Add alternate microprocessor IC item 207 to G001 and G002. Apply to in-process and future.
386SX Computer Module	178B3777G002	4	9/17/98	Add alternate sealant for Power Fail Indicator pot item 010. FDI to all earlier plants. Apply in-process and future.
Display Control 512x256	228B2112G001	20	5/19/05	Revise document cover sheet.
Display Control 512x256	228B2112G001	19	10/27/04	Change Crystal Oscillator alternate Item 501 part number for G001-G003. Apply to in-process and future.
Display Control 512x256	228B2112G001	18	3/30/01	Add alternate Crystal Oscillator item 501 to G001-G003. Apply to in-process and future.
Display Control 512x256	228B2112G001	17	8/16/00	Add alternate resistors for item 400-407 for G001-G003. Apply to in-process and future.
Display Control 512x256	228B2112G001	16	4/7/99	Add alternate CMOS IC item 202 to G001-G003. Apply to in-process and future.
Display Control 512x256	228B2112G001	16	3/28/00	Delete EEPROM alternate Item 207 from G003. Add alternate EEPROM item 207 to G001-G002. Apply to in-process and future.
Display Control 512x256	228B2112G001	15	12/21/98	Add alternateEEPROM item 207 to all groups. Apply to in-process and future.
GEDAC RAM Comm Motherboard	228B2714G003	12	8/21/00	Add alternate resistors items 402-404 to G001-G003. Apply to in-process and future.
GEDAC Module	228B2722G005	11	4/21/99	Change lock washer item 7 part #. Apply to in-process and future.
GEDAC Module	228B2722G005	10	3/26/99	Add G005. Used for Susquehanna. Eliminated RS-232 output, changed fiber-optic connector to ST style. Added three FO outputs.
16 Chan Analog Out Module	228B2846G001	8	6/28/05	Add alternate D/A Converter IC item 205 to G001. Apply to in-process and future.
16 Chan Analog Out Module	228B2846G001	7	6/2/05	Add alternate D/A converter item 205 for G001. Apply to in-process and future.
Open Drain IO Module	239B7054G002	8	10/23/00	Change alternate resistor item 414 part #. Apply to in-process and future.
Open Drain IO Module	239B7054G002	7	8/21/00	Add alternate resistors Item 410-414 to G001-G002. Apply to in-process and future.
GEIO Comm Module	239B7171G001	6	5/24/02	Add alternate resistors item 404-408 to G001. Apply to in-process and future.

APPENDIX C

Module	Susquehanna Part Number	Parts List Rev	Date	Description
GEIO Comm Module	239B7171G001	5	1/18/02	Add alternate resistor item 408 to G001. Apply to in-process and future.
Analog Module	239B7507G003	14	5/17/04	Add alternate OP AMP item 205 to G001-G004. Apply to in-process and future.
Analog Module	239B7507G003	13	11/3/00	Add alternate resistor item 401 to G001-G004. Apply to all future.
Analog Module	239B7507G003	12	8/22/00	Add alternate resistors for Item 401-405 to G001-G004. Apply to in-process and future.
Analog Module	239B7507G003	11	7/11/00	Change alternate PLD Adapter Card item 209 to G001-G004. Apply to in-process and future.
Analog Module	239B7507G003	10	7/6/00	Add alternate PLD item 209 to G001-G004. Apply to in-process and future.
Analog Module	239B7507G003	9	4/9/99	Add alternate 16-bit converter IC item 206 to G001-G004. Apply to in-process and future.
Analog Module	239B7507G003	8	6/16/97	Add alternate 16-bit converter IC Item 206 to G001-G004. Apply to in-process and future.
Power Supply Module	DA233A3785P001	2	9/7/99	Add reference dimensions. Apply to in-process and future.
Power Supply	DA265A1313P002	7	10/5/04	Add shelf-life extension process. Apply to in-process and future.
Power Supply	DA265A1313P002	6	7/10/02	Editorial corrections and added Safety-related function statement. Apply to in-process and future.
Power Supply	DA265A1313P002	5	11/2/99	Clarify burn-in test requirements. Apply to in-process and future.
Power Supply	DA265A1817P002	3	7/21/05	Updated shelf-life process. Apply to in-process and future.
Power Supply	DA265A1817P002	2	8/17/99	Clarify change post burn-in test requirements. Apply to in-process and future.

APPENDIX D

Correlation of Specific Software Design Process Documents Identified in the BTP

BTP-14 Item	NUMAC PRNM Item/comment
• Software Management Plan • Software Development Plan • Software Quality Assurance Plan • Software Configuration Management Plan • Software V&V Plan	These plans collectively address the overall design process and configuration control. For the SSES PRNM project, the corresponding requirements and controls are provided in: • Overall GE QA Program (NEDO-11209-04A Rev. 4) • NUMAC Software Configuration Management Plan (23A5161 Rev. 1) • NUMAC Software Management Plan (23A5162 Rev. 2 • NUMAC Software Verification and Validation Plan (23A5163 Rev. 2)
• Design Specifications	The top level SSES PRNM requirements are documented in a generic PRNM System Specification with an SSES-specific Specification Data sheet. Detailed requirements are defined in equipment performance specifications, user's manuals and data sheets. See LTR NEDC 32410P-A, Appendix A, Table A.1 and LTR NEDC 32410P-A, Supplement 1, Appendix A, Table A.3 for a more detailed listing of documents.
• V&V Change Report • Configuration Management Change Report	Records of supplemental or plant-specific V&V activities are documented in design records (documentation of verifications and tests) or with specific change control documents (record of changes to corporate issued documents). These records are filed in accordance with the requirements in the Plans listed above.
• Software Safety Plan • Design Safety Analysis	The NUMAC PRNM design process does not include a separate Software Safety Plan, Design Safety Analysis, or software safety organization. Safety-significant aspects of the PRNM system are included in the design requirements and confirmed as part of the overall design and V&V process.