Human Factors Engineering Assessment
Non-Proprietary

Hope Creek Power Range Neutron Monitoring Upgrade
Human Factors Assessment

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Information Notice

This is a non-proprietary version of this document, which has the proprietary information removed. Portions of the document that have been removed are indicated by a set of open and closed double square brackets as shown here [[ ]].

1 Introduction

As discussed in Section 4.1.2.5 of the HCGS PRNM LAR H15-01, an assessment of compliance with NUREG-0700 is required as part of the PSEG Configuration Change process for the PRNM upgrade. This assessment addresses the review elements identified in NUREG-0711, verifying that human factors engineering has been integrated into the PRNM upgrade. This assessment inclusively addresses the two HFE elements of the PRNM LTR (NEDC-32410P-A) “Confirmation of Plant-Specific Actions” Items 5 and 6 (Section 4.11 of LAR H15-01, ML15265A223):

- Confirm that administrative controls are provided for manually bypassing APRM/OPRM channels or protective functions, and for controlling access to the panel and the APRM/OPRM channel bypass switch
- Confirm that any changes to the plant operator's panel have received human factors reviews per plant-specific procedures.

A related NUREG-0800 Appendix 18-A assessment is provided separately.

2 HFE Program Management

This change does not impact PSEG Nuclear’s HFE Program Management. The change is evaluated under the established plant modification process and procedures, which include the following HFE considerations:

- Evaluation of operator impacts during installation
- Planning and scheduling of work to minimize disruptions
- Coordinating training and procedure updates with the modification as discussed below
- Providing maintenance and operator training on the new system prior to installation
- Involvement of Operations and Maintenance department representatives throughout the entire modification process

3 Operating Experience Review

Hope Creek performed an extensive OE review as part of this modification. The review was accomplished using the INPO OE database, correspondence with other utilities, and information from the system vendor. The following criteria were considered during this review:

3.1 Predecessor/Related Plants & Systems

The review focused on the following units with similar NUMAC PRNM systems:

- **Columbia Generating Station** – CGS is the most recent PRNM system to be licensed and installed. The Hope Creek project team visited CGS twice, once prior to system installation and once during system installation. Columbia’s PRNM system is similar to Hope Creek’s, but does not use DSS-CD. Installation and modification related OE were solicited from the Columbia project team. No formally documented OE has been reported on the Columbia PRNM system.

- **Grand Gulf Nuclear Station** – Grand Gulf had reportable event (OE 300304, Grand Gulf LER 2012-005-00) during plant startup following installation of the NUMAC PRNM system. This event was reviewed for applicable lessons learned pertaining to the Hope Creek modification.
- **Susquehanna Steam Electric Station** – Susquehanna's mode switch design is similar to Hope Creek's. OE from an APRM scram related to this design was reviewed for applicability at Hope Creek (OE 23468).
- **Peach Bottom Atomic Power Station** – Peach Bottom has a history of logic card failures in their 2 out of 4 voters (OE 35628, 301853, 312882, 302316, 300180).

None of the OE reviewed identified HFE-related problems in the NUMAC PRNM system.

3.2 Recognized Industry HFE Issues

There are no recognized industry HFE issues applicable to the NUMAC PRNM system. NUREG/CR-6400 was reviewed and one issue listed is specific to Neutron Monitoring systems: a fuse failure in an Intermediate Range Monitor that made the channel inoperable with no annunciation. As addressed elsewhere, the comprehensive self-test routines of the NUMAC PRNM system make an un-annunciated failure extremely unlikely.

3.3 Related HSI Technology

Because the PRNM system is installed in a significant portion of the BWR fleet and extensive OE is available for the system, and because of the minimal operator interaction with the system, no comparison to related HSI technology was performed.

3.4 Issues Identified by Plant Personnel

The Hope Creek PRNM project team includes representatives from Operations, Reactor Engineering, Fuels, Maintenance, Operations Training, and Maintenance Training. Because of the limited interaction operators have with the system, no human factors OE was identified.

The design decision to use Operator Display Assemblies and to place them on the 10C651 Operator's Console was based on interviews with Operations personnel and mock-ups of the proposed design in the Hope Creek Simulator.

Likewise, the decision to maintain the APRM status indicator lights on the 10C651 Operator's Console was based on input from a licensed operator on the PRNM project team.

3.5 Important Human Actions

The PRNM system performs an automatic safety function and there are no important human actions performed by plant operators on the PRNM system. Important human actions related to common cause failures of the PRNM system are addressed separately in accordance with NUREG-0800 Appendix 18-A.

4 Functional Requirements Analysis and Function Allocation

The PRNM system provides an automatic trip to RPS, and no operator action is required to accomplish the safety function. Per Section G.1 of the PRNM LTR (NEDC-32410P-A):

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No important human actions performed on the PRNM system are identified in Chapters 7 or 15 of the Hope Creek UFSAR.

The Hope Creek Probabilistic Risk Assessment Human Reliability Analysis (PRA/HRA) (HC-PRA-004) was reviewed and neutron monitoring indication is credited as an indication used to prompt manual initiation of SLC in an ATWS scenario (power ≥ 4% via APRM recorders and APRM downscale lights not illuminated) and as verification of a successful SLC injection (power is decreasing on APRM recorders). The APRM downscale lights and APRM recorders are not affected, other than deleting APRM channel E and F, and there is negligible impact on the Human Reliability Analysis.

Two existing manual operator actions are credited in the D3 analysis for PRNM (VTD 432598 Vol. 10). These operator actions are addressed separately under NUREG-0800 Appendix 18-A:

- In response to a double recirc pump trip (2RPT) event, reactor operators immediately lock the mode switch in Shutdown per procedure HC.OP-AB.RPV-0003, and this action is credited as a manual back-up to a common cause failure of the OPRM trip function. This is an existing operator action and is currently included in Operations department procedures and training.
- In response to a loss of feedwater heating event (LOFWH), procedure HC.OP-AB.BOP-0001 is entered based on indications of a feedwater heater trip. The procedure directs operators to immediately REDUCE AND MAINTAIN Reactor Power to the Pre-Feedwater Heater Trip or Isolation Value on a LOFWH. This is an existing operator action and is currently included in Operations department procedures and training.

Because no important human actions are added, changed, or deleted there are no changes to Functional Requirements Analysis or Function Allocation.

5 Task Analysis

As discussed above, no important human actions are performed on the PRNM system. Indications from the PRNM system provide input to important human actions identified in the Hope Creek PRA/HRA, but those indications are not affected, other than deleting APRM channels E and F.

Additional human actions selected for analysis include those that have existing task analyses in the Hope Creek Operations training program and those new actions that affect the Simulated Thermal Power setpoint of the NUMAC APRMs. These actions are part of the standard operating procedures for the system and are not part of abnormal or emergency operations procedures. The following additional human actions are selected for task analysis:

- Place the Rod Block Monitor In-Service (Existing)

There are no changes to this task. Both the existing and new actions consist of placing the instrument mode switch for each RBM channel into the OPERATE position.

- Manually Bypass and Restore the Rod Block Monitor (Existing)

  There are no changes to this task. Both the existing and new systems use a [[ ]] to bypass an RBM channel.

- Coordinate with I&C to Place the NIS In-Service (Existing)

  Existing actions to place the NIS in service are:

  - Set the APRM channels to OPERATE
  - Set the OPRM channels to OPERATE
  - Validate LPRM Count

  These actions are simplified by the upgrade to the NUMAC PRNM system. The LPRM count is displayed on the plant computer and no longer requires manipulation of the APRM hardware, and the OPRM channels are incorporated into the APRMs and do not require a separate action to place in operation.

- Bypass and Restore an APRM Channel (Existing)

  There are no changes to this task. Both the existing and new systems use a joystick to bypass an APRM channel. The existing system uses [[ ]], however the actions and indications are identical.

- Bypass and Restore an LPRM Detector (Existing)

  There are minimal changes to this task. In the existing system, an LPRM is placed in Bypass by changing the position of a toggle switch on the appropriate LPRM input card. In the new system, an LPRM is placed in Bypass by navigating to the Bypass Selections screen, entering the instrument password, and changing the setting on the appropriate LPRM from "OPERATE" to either "BYP/HV ON" or "BYP/HV OFF". There are no time constraints on this action.

- Place an APRM Channel in SLO Mode (New[1])

  This is a new task consisting of the following steps:

  - Bypass the APRM channel (joystick on 10C651)
  - Place the APRM Master in INOP mode (keylock switch on 10C608)
  - Enter INOP-SET mode and navigate to the SLO/BSP Mode Screen (APRM instrument on 10C608)
  - Set the SLO parameter to "YES" (APRM instrument on 10C608)
  - Confirm "SLO" is displayed in the header of the APRM display (APRM instrument on 10C608)
  - Return the instrument to OPER mode (keylock switch on 10C608)
  - Confirm "OPERATE" is displayed in the header of the APRM display (APRM instrument on 10C608)
  - Remove the APRM channel from Bypass (joystick on 10C651)

[1] This task is currently implemented by I&C Maintenance. The actions taken by operators to set the NUMAC APRM instruments to SLO mode are greatly simplified from the existing actions required by maintenance technicians.

This task must be performed on each of the four APRM channels within four hours of entering single recirculation loop operation per Hope Creek Technical Specification 3.4.1.1. Based on the simplicity of the actions and the length of time available, a detailed time required was not developed. This sequence of actions can be accomplished in much less than the time available.

- Place an APRM Channel in BSP Mode (New)

  This is a new task consisting of the following steps:

  - Bypass the APRM channel (joystick on 10C651)
  - Place the APRM Master in INOP mode (keylock switch on 10C608)
  - Enter INOP-SET mode and navigate to the SLO/BSP Mode Screen (APRM instrument on 10C608)
  - Set the BSP parameter to "YES" (APRM instrument on 10C608)
  - Confirm "BSP" is displayed in the header of the APRM display (APRM instrument on 10C608)
  - Return the instrument to OPER mode (keylock switch on 10C608)
  - Confirm "OPERATE" is displayed in the header of the APRM display (APRM instrument on 10C608)
  - Remove the APRM channel from Bypass (joystick on 10C651)

  This task must be performed on each of the four APRM channels within 12 hours of declaring the OPRM function inoperable per Action 10 of Hope Creek Technical Specification Table 3.3.1-1 as modified by License Amendment Request H15-01. Based on the simplicity of the actions and the length of time available, a detailed time required was not developed. This sequence of actions can be accomplished in much less than the time available.

- Implement Manual BSP (Existing)

  Manual BSP is implemented in accordance with the Hope Creek Technical Specifications if the OPRM function of the APRMs is declared inoperable. The operability determination is performed in accordance with plant procedures and is outside the scope of a human factors assessment. The actions taken to implement Manual BSP (restricted operating domain and enhanced operator awareness of instability symptoms) are unchanged.

6 Staffing and Qualification

Because there are minimal changes to Task Analysis, there is no change to required staffing levels or personnel qualifications. There is no change to the Emergency Preparedness program and no 10CFR50.54q evaluation is required. This change does not impact staffing or qualification with the assumption that operator training on the NUMAC PRNM is completed prior to installation.

7 Treatment of Important Human Actions

The PRNM system provides an automatic trip to RPS, and no operator action is required to accomplish the safety function. No risk-important human actions associated with the PRNM system are modeled in the PRA/HRA and the impact due to modified HSI is considered negligible.

8 Human-System Interface Design

The Human-System Interface for the NUMAC PRNM system consists of a mixture of display screens and traditional lights, indicators, recorders, and annunciators. The system provides an automatic safety function, and operator actions are primarily limited to bypassing channels, acknowledging alarms, and selecting displays. Two new functions are performed by operators at the instruments on the H1SE -10-C-608 panel: setting the APRM channel to Single Loop Operation and enabling/disabling Automatic Backup Stability Protection. The HSI consists of:

- One display screen on each instrument (10 total) in the H1SE -10-C-608 panel in the rear of the control room
- Four display screens on Operator Display Assemblies (ODAs) on the H1RL -10-C-651 operator's console
- [[ ]]
- [[ ]]
- Indicating lights for APRM Upscale, Downscale, Inop, and Bypassed status for each channel on the 10C651 operator's console
- Overhead annunciator windows driven by the PRNM system
- IRM/APRM and IRM/RBM signal recorders on the H1RL -10-C-650 vertical boards and associated switching pushbuttons on the operator's console
- Recirc flow recorders and indicators on the 10C650 vertical boards

The 10C651 Operator Console and 10C650 Vertical Board arrangements are modified to accommodate the NUMAC PRNM System ODAs and the change from 6 APRM channels to 4 APRM channels. These modifications include:

10C650:

- Removing APRM E/F channels from APRM channel status indicators and recorders
- Removing LPRM indicators and status lights at the four rod display on the vertical board
- Removing the LPRM upscale and downscale lights from the full core display on the vertical board

10C651:

- Removing RBM Status indicator lights and setup pushbuttons
- Relocating the Scram Discharge Piping Volume Piping Logic Test and Hi Level Scram Bypass controls
- Relocating the 4 remaining APRM Monitor Status lights

- Relocating the IRM Monitor Status lights and the IRM Bypass switches
- Removing the two APRM bypass switches and installing a single APRM Bypass switch
- Removing the two Recirc flow unit bypass switches and indicator lights
- Changing labeling of the APRM E/F recorder selector pushbuttons to “OFF”
- Installing 2 APRM ODAs and 2 RBM ODAs

The majority of the 10C651 changes are shown in Figure 1, with the exception of the recorder selector pushbutton changes for the removal of the APRM E/F channels.

8.1 Human Factors Analysis

Section 7 of NC.DE-TS.ZZ-1017, *Human Factors Engineering*, identifies design guidance for incorporating human factors engineering principles into design changes based on the guidance in NUREG-0700. The following design principles are applicable to the changes made by this DCP:

- Regulatory Requirements (NC.DE-TS.ZZ-1017, 7.1)
- Panel Layout (NC.DE-TS.ZZ-1017, 7.3.1)
- Control-Display Integration (NC.DE-TS.ZZ-1017, 7.3.3)
- Prevent Accidental Activation of a Control (NC.DE-TS.ZZ-1017, 7.4.2.D)
- Legend Pushbuttons (NC.DE-TS.ZZ-1017, 7.4.3.2)
- Visual Displays (NC.DE-TS.ZZ-1017, 7.5)
- Labeling (NC.DE-TS.ZZ-1017, 7.7.1)
- Demarcation (NC.DE-TS.ZZ-1017, 7.7.2)

Changes to the 10C608 PRNM panels are addressed under the PRNM LTR.

Changes to the 10C650 vertical boards consist of deletion of the LPRM indicators and bypass status lights (this information moves to the ODAs located on 10C651), removal of the LPRM upscale and downscale lights, and minor nomenclature changes to remove APRM channels E and F. These changes do not impact human factors design features and are not specifically addressed.

Panel modifications to the 10C651 operator’s panel are made in two areas: the APRM/IRM controls and the RBM/SDV controls. Changes to the 10C651 panel are addressed below:

8.1.1 Regulatory Requirements (NC.DE-TS.ZZ-1017, 7.1)

Section 7.1 identifies NUREG-0660, NUREG-0737 (including Supplement I), and NUREG-0700 as regulatory requirements applicable to human factors engineering at Hope Creek.

8.1.2 Control Room Workspace (NC.DE-TS.ZZ-1017, 7.2)

Section 7.2 addresses overall layout and environmental characteristics of the Main Control Room. These aspects are unaffected by this modification because the PRNM system indications, display, and overhead alarms remain in the same console sections as the existing system’s.

8.1.3 Panel Layout (NC.DE-TS.ZZ-1017, 7.3.1)

Subsections A, B, and C are addressed here. The remaining subsections of 7.3.1 are applicable to control stations where operators are seated or are applicable to general arrangement considerations of the control room and are not applicable to the modification scope.

Panel layout is maintained similar to the existing design. The APRM/IRM controls and indicators are currently located together in one functional group. The group includes status lights and bypass switches. The revised design maintains the IRM bypass switches and status lights, while replacing the APRM and Flow Unit bypass switches and indicators with a single APRM bypass switch and indicators. The APRM ODAs are added to the panel in this functional group, and provide additional information to the operator from the NUMAC PRNM system.

The RBM and SDV controls are currently laid out in two vertically-oriented functional groups. The controls are revised to move the SDV test pushbuttons and bypass switch to the left of the SDV valve controls, while the RBM bypass switch and ODAs are mounted in the upper portion of the panel. Functional grouping of the SDV controls and RBM controls is maintained.

The APRM and RBM ODAs are used for various indication functions primarily associated with reactivity control and are located on either side of the rod select matrix. They serve similar functions as the existing controls with additional information available to operators. The bypass switches are relocated short distances on the panel. There is no change to sequence of operations or additional operator movement associated with this modification.

The APRM and RBM ODAs are required to be read frequently and precisely during normal operations. The ODAs are mounted with the display centerline approximately 50 inches above the ground. Per the standard, these displays should be mounted between 50 and 65 inches above the standing surface.

The bypass switches are mounted approximately 54 inches above the ground. These switches are not required to be manipulated precisely or frequently and are not emergency controls, and therefore should be mounted between 34 and 70 inches above the standing surface.

8.1.4 Local Panel Design (NC.DE-TS.ZZ-1017, 7.3.2)

This human factors analysis addresses changes to the operator's console in the Main Control Room only. Section 7.3.2 is not applicable.

8.1.5 Control-Display Integration (NC.DE-TS.ZZ-1017, 7.3.3)

The APRM and IRM bypass switches have associated indicating lights that meet the requirements for Control-Display Integration. The bypass switches are located in close proximity to the left of the associated indicating lights. Labeling and spacing are used to enhance the association between the APRM and IRM bypass switches and indicator lights. For the APRMs, the indicator lights on the console were retained to assist operators with determination that all APRMs are downscale after a scram. The RBM indicator lights were not retained. RBM bypass status is displayed on the RBM ODAs in close proximity to the RBM bypass switch.

The APRM and RBM ODAs display bypass status and are located below the associated bypass switch. This is done because the ODA has pushbuttons for screen selection at the bottom edge of the display and the much taller joystick-type bypass switch would obstruct access to these pushbuttons if it was mounted below the display. This could lead to accidental activation of the bypass control as discussed below.

The SDV control relocation does not impact Control-Display Integration.

8.1.6 Controls (NC.DE-TS.ZZ-1017, 7.4) & Displays (NC.DE-TS.ZZ-1017, 7.5)

Human factors for controls and displays provided with the PRNM system are addressed in the PRNM LTR (NEDC-32410P-A). Sections 7.4 and 7.5 are generally not applicable to the rearrangement of devices on the operator's console, with the exception of subsection 7.4.2.D and 7.4.3.2, addressed below.

8.1.7 Prevent Accidental Activation of a Control (NC.DE-TS.ZZ-1017, 7.4.2.D)

[[

]] The APRM and RBM ODAs have four soft-keys used for screen selection along the bottom edge of the display. In order to prevent inadvertent operation of a bypass joystick when attempting to use the ODA buttons, the bypass switches are located above the ODAs on the console.

The ODA screen is raised from the panel surface by 1.25" but does not block access to the bypass joysticks.

8.1.8 Legend Pushbuttons (NC.DE-TS.ZZ-1017, 7.4.3.2)

The IRM system shares recorders with the APRM and RBM systems. Eight pairs of legend pushbuttons on the operator's console are used to switch the input signal between IRM/APRM or IRM/RBM channels. IRM inputs are used when the plant is not in RUN. APRM and RBM inputs are used when the plant is in RUN. Due to the deletion of the APRM E and F channels, those inputs to the switching logic are being shorted, and the pushbutton legends for those two pushbuttons are being changed from "APRM E" and "APRM F" to "OFF". Operators will continue switching the recorders. Button nomenclature changes are addressed in revised operations procedures.

8.1.9 Visual Displays (NC.DE-TS.ZZ-1017, 7.5)

The design of the ODA displays is addressed under the PRNM LTR and is not addressed here. However, section 7.5 of NC.DE-TZ.ZZ-1017 does address glare considerations for displays. The PRNM ODAs are supplied with a matte finish to help reduce glare. The displays are mounted in the vertical section of the operator's console, similarly to the existing Digital Feedwater Control System (DFCS) and Digital Electro-Hydraulic Control (DEHC) LCD displays. Neither the DFCS nor DEHC display has a glare shield, and glare has not been a problem for either display. One existing NUMAC ODA for the Rod Worth Minimizer is mounted on the horizontal section of the operator's console and no glare problems have been noted with that display.

Based on the above considerations, glare is not expected to be a problem and no glare shields are included in the design.

8.1.10 Annunciators (NC.DE-TS.ZZ-1017, 7.6)

The existing PRNM Overhead Annunciator windows are reused for the NUMAC PRNM system, including annunciators currently assigned to the OPRM system. There are minor annunciator nomenclature changes, but the window and associated alarm response action locations are unchanged. Appropriate color coding is maintained. The overall human factors design of the Overhead Annunciator system is not affected.

8.1.11 Labeling (NC.DE-TS.ZZ-1017, 7.7.1)

Labels are provided for the APRM, IRM, and RBM pushbuttons and indicating lights, and for the SDV controls. The ODAs are provided with a built-in label at the top of each ODA.

The labels provided are above the associated control or indication and are visible during control actuation. The labels do not obscure any other information. The labels are clear and unambiguous, and use common abbreviations for APRM, IRM, and RBM where required due to space limitations (SDV is spelled out as there is adequate space in that area). Indicating lights for multiple channels are labeled appropriately in alphabetical order. Control position labels for the bypass switches are maintained similar to the existing design.

Label font and character heights are in accordance with existing control board label drawings. Labels are mounted using adhesive and are oriented horizontally.

The existing IRM, APRM, and Flow Unit controls and indications use labeling hierarchy with Major, Subordinate, and Component labels. The Major labels identify IRM/APRM/Recirc Flow Monitoring RPS Trip Channel A(B), the Subordinate labels differentiate between Monitor Status and Monitor Bypass, and the Component labels denote individual channels and bypass switches.

The revised NUMAC PRNM system does not have APRM channels associated with a specific RPS Trip System due to the 2-out-of-4 voters, so identification of RPS Trip Systems is no longer appropriate. Panel space is limited due to the addition of ODAs. Hierarchical labeling is not used for the IRM, APRM, or RBM bypass switches and indicator lights. Component labels are used to identify each device and contain sufficient information to accurately identify the function and channel.

Hierarchical labels are maintained for the SDV controls.

8.1.12 Demarcation (NC.DE-TS.ZZ-1017, 7.7.2)

Demarcation lines are used to separate the various control groups. The lines are modified to mark the boundary between the RBM and SDV controls. The line separating the RPS Trip System A and RPS Trip System B groups of APRM and IRM controls is removed as this division is no longer applicable to the APRM channels and the layout precludes maintaining the demarcation for the IRM controls. Demarcation lines used match the existing design.

8.1.13 Color Padding (NC.DE-TS.ZZ-1017, 7.7.3) & Mimics (NC.DE-TS.ZZ-1017, 7.7.4)

Color padding and mimics are not currently used on the affected areas of the control board and are not added per this design.

8.1.14 Coding Techniques (NC.DE-TS.ZZ-1017, 7.8)

No specific coding techniques are applicable to the operator's console modification. Existing coding techniques used in the Main Control Room are not affected.

8.1.15 Computers (NC.DE-TS.ZZ-1017, 7.9)

Human factors considerations for the NUMAC PRNM equipment are addressed in the PRNM LTR (NEDC-32410P-A). LPRM Upscale and Downscale (and new INOP and Bypassed) indications are added to a new plant computer screen developed from the existing LPRM screen. This new screen is developed to PSEG standards for plant computer screens, including fonts and font size, line weights, and color coding.

8.2 APRM / RBM Operator Display Assemblies

Per the PRNM LTR (NEDC-32410P-A) Vol. 1 Section 4.4.1.9, the PRNM NUMAC ODAs are designed to meet the applicable guidelines established in NUREG-0700.

9 Procedure Development

Changes to procedures are developed in accordance with Hope Creek's existing procedure development program. This program is described in the Hope Creek UFSAR and meets the criteria of NUREG-0711, including procedure bases, the procedure writer's guide, procedure elements, procedure maintenance, and personnel access and use of procedures.

Integrated Operating procedures are updated to incorporate setpoint changes and to incorporate startup testing activities associated with the NUMAC PRNM system.

The Neutron Monitoring and Rod Block Monitor system operating and abnormal operating procedures are updated to reflect changes to the design of the PRNM system (reduction from 6 to 4 channels, 2 out of 4 voting functionality, etc.) and changes to operator interfaces.

Maintenance procedures are updated with maintenance requirements and procedures for the NUMAC PRNM equipment.

Surveillance procedures are updated to perform the TS required testing of the new instruments and revised setpoints.

Alarm Response procedures are impacted by nomenclature changes to the overhead annunciator windows and by addition of more detailed plant computer alarm points. The annunciator changes also affect other procedures which reference the annunciators. There are no new Operator actions required to support alarm responses.

No Emergency Operating Procedures are affected by this modification.

Modified procedures for the PRNM system will be validated during Site Acceptance Testing prior to installation of the system. Impacted procedures that involve interfaces to other plant systems will receive tabletop reviews prior to installation of the PRNM system.

No computer-based procedures are implemented by this modification.

9.1 Administrative Controls

The following administrative controls identified in the NUMAC PRNM Operations and Maintenance manuals are incorporated into the applicable Hope Creek procedures:

9.1.1 LPRM Instrument Keylock Switch

[[

]] (Ref. NEDC-33864P Appendix F2 pg 43 of 79)

Procedure HC.OP-SO.SE-0001, *Neutron Monitoring System Operation*, includes a requirement to [[

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9.1.2 I/V Curve/Adjust HVPS Ouput

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]] (Ref. NEDC-33864P Appendix F2 pg 51 of 79)

This action is precluded by the design of the Hope Creek Plant Computer interface to PRNM. [[

]] Additionally, a precaution is added to procedure HC.IC-DC.SE-0001, *LPRM Current-Voltage Curve and Capacitance Discharge Test*, to [[ ]]

9.1.3 I/V Curve Auto-Bypass

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]] (Ref. NEDC-33864P Appendix F2 pg 51 of 79)

Procedure HC.IC-DC.SE-0001 is updated to include a step to determine [[

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9.1.4 APRM GAF/LPRM GAF Delay

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]] (ref. NEDC-33864P Appendix G pg 223 of 227)

Procedure HC.IC-CC.SE-0029, *Nuclear Instrumentation System LPRM Gain Calibration*, [[

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9.1.5 Manual BSP

As described in Section 7 and in the Technical Specification (TS) changes documented in the approved DSS-CD Licensing Topical Report (LTR) NEDC-33075P-A, Rev. 8, [[

]] (NEDC 33864P Appendix I pg I-9)

Procedures HC.OP-AB.RPV-0003 and HC.RE-AB.ZZ-0001 include guidance for entry into Manual BSP, and the actions in those procedures are included in Operator training.

9.1.6 Control Room Access

Requirement: The design shall permit the administrative control of access to safety system equipment. These administrative controls shall be supported by provisions within the safety systems, by provision in the generating station design, or by a combination thereof. The PRNM safety system equipment is located in the main control room, to which access is controlled by administrative means. (Ref. NEDC 33864P Appendix O, pg O-9)

Procedure SY-AA-103-511, *Request for Unescorted Access*, describes security card reader access levels, which are used to limit Main Control Room access to personnel with a valid need. In addition, the Main Control Room is required to be staffed at all times and access to the Main Control Room is controlled administratively by the control room staff in accordance with procedure OP-AA-103-101, *Control Room Access Control*.

9.1.7 Bypass Switch Access & Control

Per Section 4.4.1.1.14 of the PRNM LTR (NEDC-32410P-A), [[

]]

The [[ ]] is located on the [[ ]] in the Main Control Room. The Main Control Room is required to be staffed at all times and access to the [[

]] by the control room staff in accordance with procedure OP-AA-103-101, *Control Room Access Control*.

9.1.8 PRNM System Access

Per Section 4.4.1.1.18 of the PRNM LTR (NEDC-32410P-A), regarding trip settings, [[

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As stated in Section 3.13 to the SER and Section 5.3.13 of the LTR, the PRNM System has [[

]] As stated in Section 3.17 to the SER, setpoint adjustments, calibrations, and testing processes are performed using the NUMAC operator interface panel. Access to panel functions is controlled via [[

]] User interfaces and controls are described in Section 5.3.18 of the LTR. The NRC staff found these PRNM System design features and administrative control to be acceptable, per the SER. (NEDC 33864P Appendix O, pg O-9)

At Hope Creek control of the PRNM system keys are maintained under the plant key control procedure, OP-HC-108-101-1002, *Key Control - Hope Creek*. Physical access to the system in the rear of the Main Control Room is controlled administratively via multiple levels of security (described above), and administrative control of entry to the Main Control Room by both the Control Room Supervisor and Reactor Operators.

9.1.9 RBM Nulling on Rod Selection

GEH recommends that HCGS implement a [[

]] (NEDC-33864P Appendix P2, pg 15)

This requirement is to ensure that the [[

]] This requirement is implemented in procedure HC.OP-SO.SF-0001, *Reactor Manual Control System Operation*.

10 Training Program Development

Training will be conducted in accordance with the requirements of PSEG Nuclear's INPO-accredited training program as described in UFSAR Section 13.2. The training program is formulated to provide an organization qualified to operate, maintain and support the facilities in a safe and reliable manner. The training program has been developed from a systematic analysis of job requirements using job and task analysis where available. This approach is consistent with Nuclear Regulatory Commission (NRC) regulations and the Institute of Nuclear Power Operations (INPO) recommendations for accreditation of training programs.

PSEG has developed draft Operations and Maintenance training plans specific to the PRNM upgrade. These plans address the changes required to training documentation, identify which personnel will be trained, identify what training is required and the objectives of that training, and include a schedule for both pre- and post-installation training.

11 Human Factors V&V

NUREG-0711, *Human Factors Engineering Program Review Model*, identifies that Human Factors Verification and Validation evaluations are used to confirm that a final design conforms to Human Factors Engineering (HFE) design principles and that it enables personnel to successfully and safely perform their tasks to achieve operational goals. The three evaluation types spelled out in NUREG-0711 include:

- Human Systems Interface (HSI) Task Support Verification - an evaluation to verify that the HSI supports personnel task requirements as defined by task analyses.
- HFE Design Verification - an evaluation to verify that the HSI is designed to accommodate human capabilities and limitations as reflected in HFE guidelines such as those provided in NUREG-0700, *Human-System Interface Design Review Guidelines*.

- Integrated System Validation - an evaluation using performance-based tests to determine whether an integrated system design (i.e., hardware, software, and personnel elements) meets performance requirements and acceptably supports safe operation of the plant.

11.1 HSI Task Support Verification - Discussion:

This verification ensures that the HSI provides all alarms, information, and control capabilities required for personnel tasks. The upgrade to the Power Range Neutron Monitor System (PRNMS) does not impact reactor operating parameters or the functional requirements of the Average Power Range Monitoring (APRM) system. The replacement equipment continues to provide information, enforce control rod blocks, and initiate reactor scrams under appropriate specified conditions. As such, the operator actions remain unchanged when upgrading to the NUMAC PRNM System, in that the same actions/responses occur with data received from the digital upgrade as with the analog APRM system that is being replaced. As stated above, this means that no operator actions are being changed, added, or deleted as a result of the PRNMS upgrade. Because there are no significant changes to operator actions or functions, no new task analyses were performed. Hence, with no operator actions changing, or new task analyses performed, HSI Task Support Verification is not required for the upgrade to the NUMAC PRNM System.

11.2 HFE Design Verification - Discussion:

This verification ensures that the characteristics of the HSI and the environment in which it is used conform to HFE guidelines. Section 4.4.1.9, "Human Factors," of the PRNM LTR, NEDC-32410P-A identifies that:

> *"The design of the PRNM replacement equipment meets the intent of NUREG-0700 as applicable to the back panel equipment. The base design for the plant operator's panel uses the existing operator interface devices, so there is no effect on the plant human factor's evaluations. The digital NUMAC Operator's Display Assembly alternate for the plant operator's panel display has been designed to meet NUREG-0700 to the extent possible."*

PSEG is employing the alternate ODA option for the replacement NUMAC PRNM System. The Human Factors Engineering (HFE) review included in the LTR as well as the HFE review of operator panel changes above ensures that the requirements of NUREG-0700 are met.

11.3 Integrated System Validation - Discussion:

Integrated system validation is the process by which an integrated system design (i.e., hardware, software, and personnel elements) is evaluated using performance-based tests to determine whether it acceptably supports safe operation of the plant. Section 4.4.1.10, 'Training and Maintenance", of the LTR (NEDC-32410P-A) states:

> *The replacement PRNM equipment is designed to facilitate maintenance and minimize necessary operational training. The information presented is structured to be easily understood by a user familiar with the Neutron Monitoring System and its primary functions.*

PSEG confirmed the LTR's diagnosis of minimal operator impact during the Factory Acceptance Test (FAT) conducted during March 2016 using the new HCGS hardware attached to a plant simulator. During the FAT the following activities were conducted:

- Classroom training for selected personnel from Operations, Maintenance and Engineering
- Hands-on training for selected personnel from Operations and Maintenance
- Verification and validation of Operations and Maintenance procedures

NUREG-0711, Section 11.4.3, "Integrated System Validation," states the following:

> *For the case of plant modifications, the applicability and scope of integrated system validation may vary. An integrated system validation should be reviewed for all modifications that may (1) change personnel tasks; (2) change tasks demands, such as changing task dynamics, complexity, or workload; or (3) interact with or affect HSIs and procedures in ways that may degrade performance. Integrated system validation may not be needed when a modification results in minor changes to personnel tasks such that they may reasonably be expected to have little or no overall effect on workload and the likelihood of error.*

For the upgrade to the NUMAC PRNM System, an Integrated System Validation is not warranted as there is no change in important human actions for the replacement hardware. Operator tasks remain unchanged; hence there is no impact to task dynamics, complexity or workload for the Operations staff. The HSI is designed such that the replacement PRNMS provides the same information as the legacy Neutron Monitoring System such that it is a reasonable expectation that there will be little or no overall effect on the operations staff with regards to workload or the likelihood of an error.

12 Design Implementation

Installation activites for the PRNM system will disrupt the center section of the operator's console. The indications and controls affected are the IRM indicators and bypass switches, APRM indicators and bypass switches, RBM indicators and bypass switch, and the Scram Discharge Volume bypass switch and logic test pushbuttons. The SRM and IRM systems will remain operable and will perform their design functions. A temporary modification will relocate the IRM bypass switches to the IRM panels in the rear of the control room for the duration of the PRNM installation outage. Physical access to the RPS Trip manual initiation and reset controls, IRM range switches, IRM and SRM detector drive controls, SDV valve controls, MSIV test pushbuttons, and Rod Select Matrix may be restricted for short periods of time during modification of the 10C651 operator's console. The installation is planned and the impact of the installation activities is risk-assessed in accordance with plant procedures.

Pre-fabricated panel sections and cutting templates are used to minimize the time required to modify the operator's console. The outage planning process will schedule the work to minimize disruptions to outage activities.

The PRNM system is installed in test racks in the Control Room Computer Room approximately two years prior to installation in the plant. Revised procedures and training are validated on the system prior to installation and/or training classes.

Operator training is scheduled in several phases:

- Pre installation training (1/2018) - This will be the first training provided to entire licensed operator population. This training will be performed utilizing the computer room PRNMs and/or the simulator PRNM depending on simulator installation.
- Just in time training (4/2018) - This training will occur during the outage while installation is occurring. It will contain up to date information that may not have been covered in the pre installation training. This training will occur in the classroom and/or simulator once the simulator installation is completed.
- Gap training post outage - This training will occur in a training segment following the installation (Spring/Summer 2018) to cover any gaps identified between the previous training and final state of the project.

Maintenance training includes an initial "train the trainers" in 4th quarter of 2016, with detailed training updates developed through the 1st and 2nd quarters of 2017. Maintenance training on the new system will begin in 4th quarter 2017 to be ready for system installation in 2nd quarter 2018.

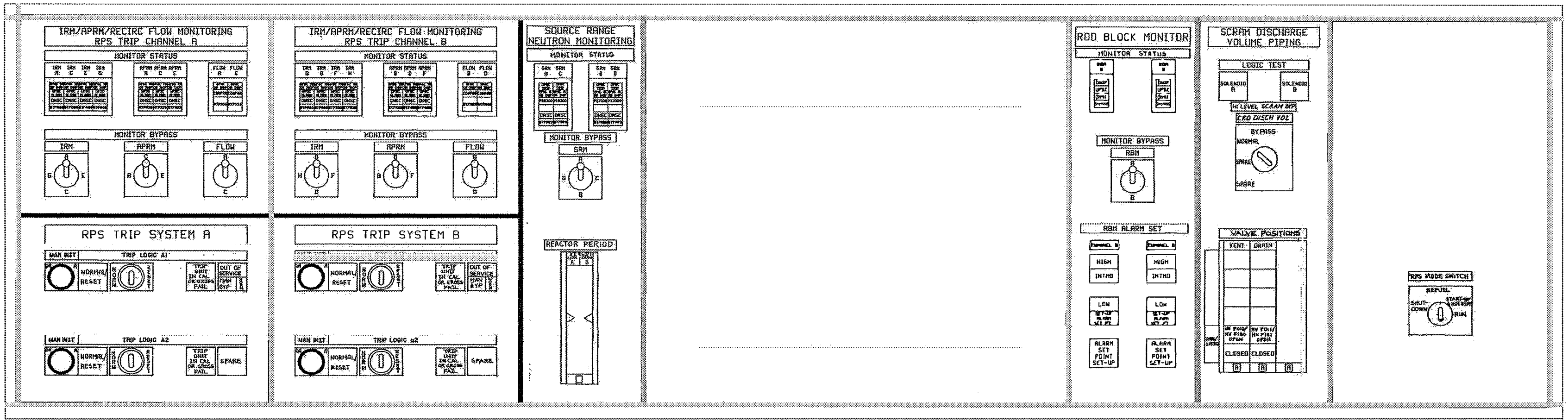
Startup and initial operations will be monitored and any procedural or training deficiencies will be entered into PSEG's corrective action process for tracking and resolution. Evaluation of the training process for the PRNM system will occur 6-12 months following installation. It will include a review of system performance and personnel operation of the system since installation to determine if any further training is required or if the initial training was sufficient.

This upgrade is not part of a control room modernization program.

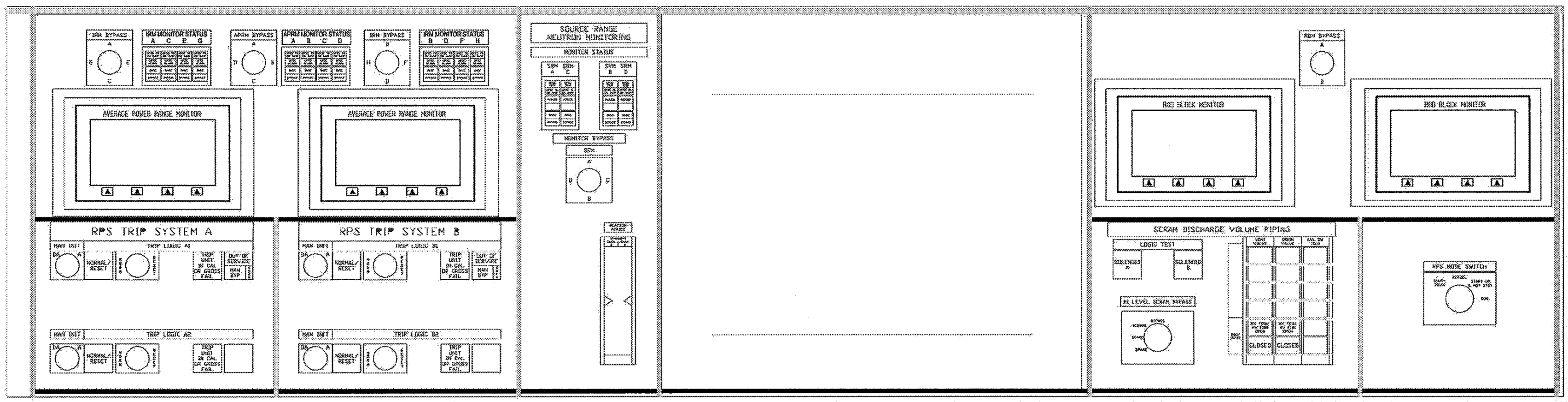
13 Human Performance Monitoring Strategy

NUREG-0711 identifies that, *"A human performance monitoring strategy will help to provide reasonable assurance that the confidence developed by the completion of the integrated system validation is maintained over time."*

As identified above, with no changes being made to any important human actions with the installation of this replacement system, no Integrated System Validation is warranted. Since the system provides automatic functions (e.g., input to Reactor Protection System scram signals, input to the Reactor Manual Control System control rod withdrawal blocks), the same as the existing analog NMS systems, there are no changes in required operator actions. Therefore, there is no impact to Hope Creek's existing Human Performance Monitoring Program.



EXISTING 10C651 OPERATOR CONSOLE



NEW 10C651 OPERATOR CONSOLE MODIFICATIONS

NOTES:
1. SEE BCP SECTION 11, '10C651 MODIFICATION' FOR DETAILED DESCRIPTION OF CONSOLE CHANGES.

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HOPE CREEK PRNM UPGRADE
10C651 OPERATOR CONSOLE MODIFICATIONS

SH. 1 OF 1

Hope Creek PRNM Upgrade
Human Factors Assessment
Figure 1