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PSEG
Nuclear LLC

Order EA-12-051

LR-N15-0092

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, DC 20555-0001

Hope Creek Generating Station
Renewed Facility Operating License No. NPF-57
NRC Docket No. 50-354

Subject: Hope Creek Generating Station Compliance with NRC Order to Modify Licenses with Regard to Reliable Spent Fuel Pool Instrumentation (Order EA-12-051) and Responses to Requests for Additional Information

References:

1. NRC Order EA-12-051, "Order Modifying Licenses with Regard to Requirements for Reliable Spent Fuel Pool Instrumentation," dated March 12, 2012

2. NRC Letter, "Hope Creek Generating Station, Unit No. 1 - Interim Staff Evaluation and Request for Additional Information Regarding the Overall Integrated Plan for Implementation of Order EA-12-051, Reliable Spent Fuel Pool Instrumentation (TAC NO. MF1031)," dated November 22, 2013

On March 12, 2012, the Nuclear Regulatory Commission (NRC) issued Order EA-12-051 (Reference 1), Attachment 2 of which establishes requirements for reliable spent fuel pool level instrumentation (SFPLI) for operating reactors and construction permit holders. PSEG has installed a primary and backup channel of SFPLI in response to NRC Order EA-12-051. Attachment 1 provides a summary of Hope Creek Generating Station (HCGS) compliance with the requirements of Attachment 2 to NRC Order EA-12-051 in accordance with Condition IV.C.3 of the Order. Attachment 2 provides HCGS responses to NRC requests for additional information in Reference 2.

There are no regulatory commitments contained in this letter.

If you have any questions or require additional information, please do not hesitate to contact Mr. Gary Wohler at 856-339-5020.

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

Executed on July 28, 2015
(Date)

Sincerely,

Paul J. Davison

Paul J. Davison
Site Vice President
Hope Creek Generating Station

Attachment 1 – Hope Creek Generating Station Compliance with NRC Order EA-12-051 Requirements for Reliable Spent Fuel Pool Level Instrumentation

Attachment 2 – Hope Creek Generating Station Response to Interim Staff Evaluation and Request for Additional Information Regarding the Overall Integrated Plan for Implementation of Order EA-12-051 "Reliable Spent Fuel Pool Instrumentation"

cc: Mr. William Dean, Director of Office of Nuclear Reactor Regulation
Mr. Daniel Dorman, Administrator, Region I, NRC
Ms. Carleen Parker, Project Manager, NRC
Mr. Justin Hawkins, NRC Senior Resident Inspector, Hope Creek
Mr. Patrick Mulligan, Manager IV, NJBNE
Mr. Thomas MacEwen, Hope Creek Commitment Tracking Coordinator
Mr. Lee Marabella, PSEG Corporate Commitment Coordinator

***(The bcc list should not be submitted as part of the DCD submittal - remove this page prior to submittal and make the bcc distribution accordingly)***

bcc: President and Chief Nuclear Officer
Vice President – Hope Creek
Vice President - Operations Support
Director - Nuclear Oversight
Director - Regulatory Affairs
Plant Manager - Hope Creek
Manager - Regulatory Assurance - Hope Creek
Senior Project Manager – Fukushima Site Improvements Project
Manager - Licensing
Document Control

LR-N15-0092

**Attachment 1**

**Hope Creek Generating Station Compliance with NRC Order EA-12-051 Requirements for Reliable Spent Fuel Pool Level Instrumentation**

**Hope Creek Generating Station Compliance with NRC Order EA-12-051 Requirements for Reliable Spent Fuel Pool Level Instrumentation**

Order Requirement

"All licensees identified in Attachment 1 to this Order shall have a reliable indication of the water level in associated spent fuel storage pools capable of supporting identification of the following pool water level conditions by trained personnel: (1) level that is adequate to support operation of the normal fuel pool cooling system, (2) level that is adequate to provide substantial radiation shielding for a person standing on the spent fuel pool operating deck, and (3) level where fuel remains covered and actions to implement make-up water addition should no longer be deferred."

Hope Creek Generating Station Compliance

Hope Creek Generating Station (HCGS) has installed spent fuel pool level instrumentation (SFPLI) to provide reliable indication of SFP water level. PSEG identified the three required levels for monitoring SFP level and incorporated them into the design of the HCGS SFPLI and Operations procedure guidance. The range of the HCGS SFPLI encompasses water levels from above the Level 1 value down to approximately four inches above Level 3.

Order Requirement

1. "The spent fuel pool level instrumentation shall include the following design features:"

1.1 "Instruments: The instrumentation shall consist of a permanent, fixed primary instrument channel and a backup instrument channel. The backup instrument channel may be fixed or portable. Portable instruments shall have capabilities that enhance the ability of trained personnel to monitor spent fuel pool water level under conditions that restrict direct personnel access to the pool, such as partial structural damage, high radiation levels, or heat and humidity from a boiling pool."

HCGS Compliance

The SFPLI consists of a primary and backup channel, both of which are permanent, fixed instrument channels.

Order Requirement

1.2 "Arrangement: The spent fuel pool level instrument channels shall be arranged in a manner that provides reasonable protection of the level indication function against missiles that may result from damage to the structure over the spent fuel pool. This protection may be provided by locating the primary instrument channel and fixed portions of the backup instrument channel, if applicable, to maintain instrument channel separation within the spent fuel pool area, and to utilize inherent shielding from missiles provided by existing recesses and corners in the spent fuel pool structure."

HCGS Compliance

The SFPLI is provided with reasonable protection from missiles that may result from damage to the structure over the SFP. Protection is provided by separation of the probes in the pool (approximately 30 feet apart). The probes are mounted below the top of the pool and the cables exiting the probe heads are routed into a wiring trough at the edge of the pool beneath protective cover plates. Generation of internal missiles due to a seismic event is precluded by Seismic Category I or II/I design of the structures, systems, and components within the Seismic Category I Reactor Building. Also, the location of the SFP and probes within the Seismic Category I Reactor Building provides inherent protection from external missile hazards.

Order Requirement

1.3 "Mounting: Installed instrument channel equipment within the spent fuel pool shall be mounted to retain its design configuration during and following the maximum seismic ground motion considered in the design of the spent fuel pool structure."

HCGS Compliance

The SFPLI probes are mounted to structures that are secured to the concrete floor of the refueling deck. The probe mounting brackets are shown by analysis to withstand safe shutdown earthquake and hydrodynamic forces for the specific HCGS configuration. The SPFLI probe structures have been designed in accordance with the HCGS Seismic II/I criteria. The HCGS Seismic II/I allowable stresses and loading combinations that account for safe shutdown earthquake loads are the same as those used for Seismic Category I design. The anchor bolts that attach the mounting structure to the refuel floor are safety-related, Seismic Category I.

Order Requirement

1.4 "Qualification: The primary and backup instrument channels shall be reliable at temperature, humidity, and radiation levels consistent with the spent fuel pool water at saturation conditions for an extended period. This reliability shall be established through use of an augmented quality assurance process (e.g., a process similar to that applied to the site fire protection program)."

HCGS Compliance

The SFPLI is designed to provide reliable operation at temperature, humidity and radiation levels consistent with beyond design basis (BDB) conditions using the NRC-endorsed guidance of NEI 12-02, and is subject to the HCGS augmented quality process.

Order Requirement

1.5 "Independence: The primary instrument channel shall be independent of the backup instrument channel."

HCGS Compliance

Each SFPLI channel is independent of the other, consisting of separate sensor probes and electronics packages.

Order Requirement

1.6 "Power supplies: Permanently installed instrumentation channels shall each be powered by a separate power supply. Permanently installed and portable instrumentation channels shall provide for power connections from sources independent of the plant ac and dc power distribution systems, such as portable generators or replaceable batteries. Onsite generators used as an alternate power source and replaceable batteries used for instrument channel power shall have sufficient capacity to maintain the level indication function until offsite resource availability is reasonably assured."

HCGS Compliance

The SFPLI primary and backup channels are permanently installed and powered from separate power supplies. Each channel is powered from a separate vital instrument bus with uninterruptible power supply (UPS). Each channel has replaceable battery backup in the event of a loss of vital instrument bus or UPS. The SFP level instrument system provides at least seven days of battery life assuming typical use and accounting for postulated post-event environmental conditions.

Order Requirement

1.7 "Accuracy: The instrument channels shall maintain their designed accuracy following a power interruption or change in power source without recalibration."

HCGS Compliance

The SFPLI channels maintain their design accuracy following power interruption such as that which may occur due to the transition from normal AC power to the battery backup, as demonstrated by power interruption testing performed by the SFPLI vendor.

Order Requirement

1.8 "Testing: The instrument channel design shall provide for routine testing and calibration."

HCGS Compliance

The SFPLI design supports routine testing and calibration. Testing and calibration as recommended by the SFPLI vendor may be performed in-situ, and is part of the HCGS Preventive Maintenance (PM) program.

Order Requirement

1.9 "Display: Trained personnel shall be able to monitor the spent fuel pool water level from the control room, alternate shutdown panel, or other appropriate and accessible location. The display shall provide on-demand or continuous indication of spent fuel pool water level."

HCGS Compliance

The SFPLI primary and back-up instrument channel displays are located in the Lower Control Equipment Room, which is located two levels below the Main Control Room (MCR) and is easily accessible. The SFPLI is designed to provide continuous or on-demand indication of SFP water level.

Order Requirement

2. "The spent fuel pool instrumentation shall be maintained available and reliable through appropriate development and implementation of the following programs:"

2.1 "Training: Personnel shall be trained in the use and the provision of alternate power to the primary and backup instrument channels."

HCGS Compliance

HCGS personnel participated in training provided by the SFPLI vendor, and applied the systematic approach to training for operations, maintenance and technical staff. Individuals from HCGS Controls Maintenance and Training departments attended vendor training. Training conducted for Operations shift personnel included the location and use of the SFPLI, associated procedure changes, and the provision of alternate power to the primary and backup SFPLI channels.

Order Requirement

2.2 "Procedures: Procedures shall be established and maintained for the testing, calibration, and use of the primary and backup spent fuel pool instrument channels."

HCGS Compliance

The SFPLI is subject to HCGS procedures and processes for the testing, calibration, and use of the primary and backup channels. Channel checks are performed as part of routine operator rounds and documented in accordance with Operations procedures. Testing and calibration of the SFPLI is part of the HCGS PM program. Operations procedures direct the use of the SFPLI displays.

Order Requirement

2.3 "Testing and Calibration: Processes shall be established and maintained for scheduling and implementing necessary testing and calibration of the primary and backup spent fuel pool level instrument channels to maintain the instrument channels at the design accuracy."

HCGS Compliance

The SFPLI primary and backup channels are subject to HCGS PM processes for scheduling and implementing testing and calibration activities to maintain the channels at their design accuracy.

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**Attachment 2**

# Hope Creek Generating Station Response to Interim Staff Evaluation and Request for Additional Information Regarding the Overall Integrated Plan for Implementation of Order EA-12-051 "Reliable Spent Fuel Pool Instrumentation"

**Hope Creek Generating Station (HCGS)**
**Response to Interim Staff Evaluation and Request for Additional Information**
**Reliable Spent Fuel Pool Instrumentation**

**Section 3.5 Design Features: Mounting**

**Background to RAI #1, #2 and #3**

The ISE states, in part,

> The NRC staff notes that further information regarding mounting of the SFP level instrumentation is not currently available for review and that in its letter dated August 20, 2013, the licensee indicated that the information will be provided to the staff in the August 2014, six-month OIP update. The staff has identified these requests as:

**RAI #1**

Please provide the following:

a) The design criteria that will be used to estimate the total loading on the mounting device(s), including static weight loads and dynamic loads. Describe the methodology that will be used to estimate the total loading, inclusive of design basis maximum seismic loads and the hydrodynamic loads that could result from pool sloshing or other effects that could accompany such seismic forces.

b) Indicate in a schematic, the portions of the level sensor that will serve as points of attachment for mechanical/mounting or electrical connections.

c) A description of the manner by which the mechanical connections will attach the level instrument to permanent SFP structures so as to support the level sensor assembly.

*(This information* was *previously requested* as *RAI-3 in NRC letter dated July* 22, *2013)*

**PSEG Response to RAI #1**

a) The mounting structures are secured at the concrete foundation surrounding the spent fuel pool and are qualified for Seismic II/I requirements, accounting for static weight loads and using seismic accelerations taken from G-0051(Q), “Category 1 Structures, Floor Response Spectra for Seismic Analysis of Equipment and Components for Hope Creek Generating Station” (Reference 1). The

anchor bolts that attach the mounting structures to the refuel floor are safety-related, Seismic Category I. The loading on the mounting devices and the effect of additional weight of the probe and mounting on the refuel floor are evaluated using General Civil-Structural Design Criteria for the Hope Creek Generating Station (Reference 2). The loading on the probe mount and probe body includes both seismic and hydrodynamic loading by utilizing HCGS design basis seismic response spectra applicable to the installed location. The static weight load is accounted for in the analytical model performed by the instrument vendor (MOHR) using the methodology provided in IEEE 344-2004 (Reference 3).

The seismic loading response of the probe and mount is modeled by MOHR using finite element modeling software. A detailed computational spent fuel pool (SFP) hydrodynamic model has been developed using ANSYS computational fluid dynamics code. The computational model accounts for multi-dimensional fluid motion, pool sloshing, and loss of water from the SFP. The ANSYS derived fluid motion profile in the pool at the installation point and resultant distributed hydrodynamic loading terms are combined with the calculated seismic loading terms in the finite element model to provide a conservative estimate of the combined seismic and hydrodynamic loading terms for the probe and probe mount for the selected location of the sensor probes.

b) The support structures are anchored to the concrete curb around the SFP above the refueling deck as shown in the following figures:

| Figure | Description |
|---|---|
| 1a | Section View – West Probe |
| 1b | Section View – Northeast Probe |
| 2 | Mounting Plate Detail |
| 3 | Plan View – Northeast Probe |
| 4 | Plan View – West Probe |

c) The level sensor is designed to be attached near its upper end to the support structure as shown in Figures 1a, 1b, 2, 3, and 4.

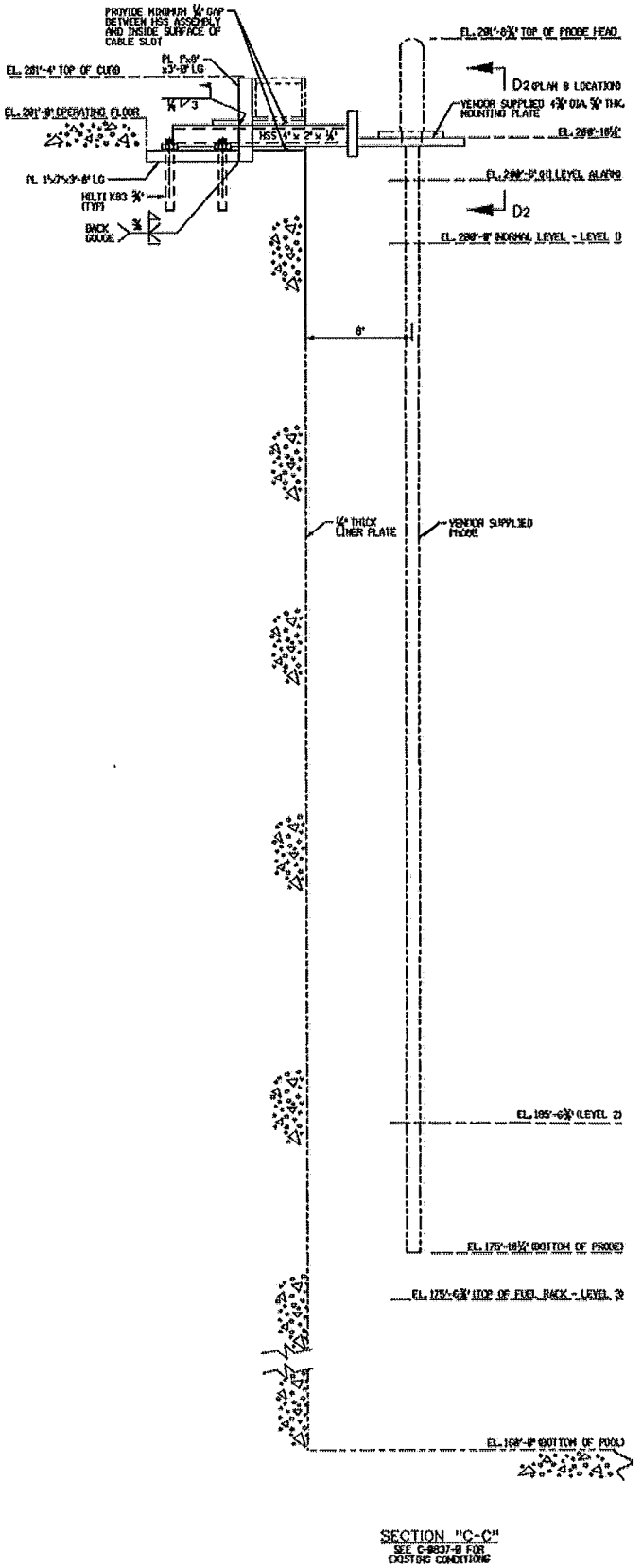

PROVIDE MINIMUM ½" GAP BETWEEN HSS ASSEMBLY AND INSIDE SURFACE OF CABLE SLOT
EL. 281'-4" TOP OF CURB
PL 1"x8" x3'-8" LG
EL. 281'-9" OPERATING FLOOR
HSS 4" x 2" x ¼"
EL. 298'-8¾" TOP OF PROBE HEAD
D2 PLAN B LOCATION
VENDOR SUPPLIED 4¾" DIA. ⅝" THK. MOUNTING PLATE
EL. 298'-1¾"
EL. 298'-5" OIL LEVEL ALARM
D2
EL. 298'-8" NORMAL LEVEL - LEVEL 0
PL 1½"x3'-8" LG
HILTI KB3 ⅜" (TYP)
BACK GOUGE
8"
½" THICK LINER PLATE
VENDOR SUPPLIED PROBE
EL. 185'-6¾" (LEVEL 2)
EL. 175'-1¾" (BOTTOM OF PROBE)
EL. 175'-6¾" (TOP OF FUEL RACK - LEVEL 3)
EL. 164'-8" (BOTTOM OF POOL)
SECTION "C-C"
SEE C-6837-8 FOR EXISTING CONDITIONS

Figure 1a

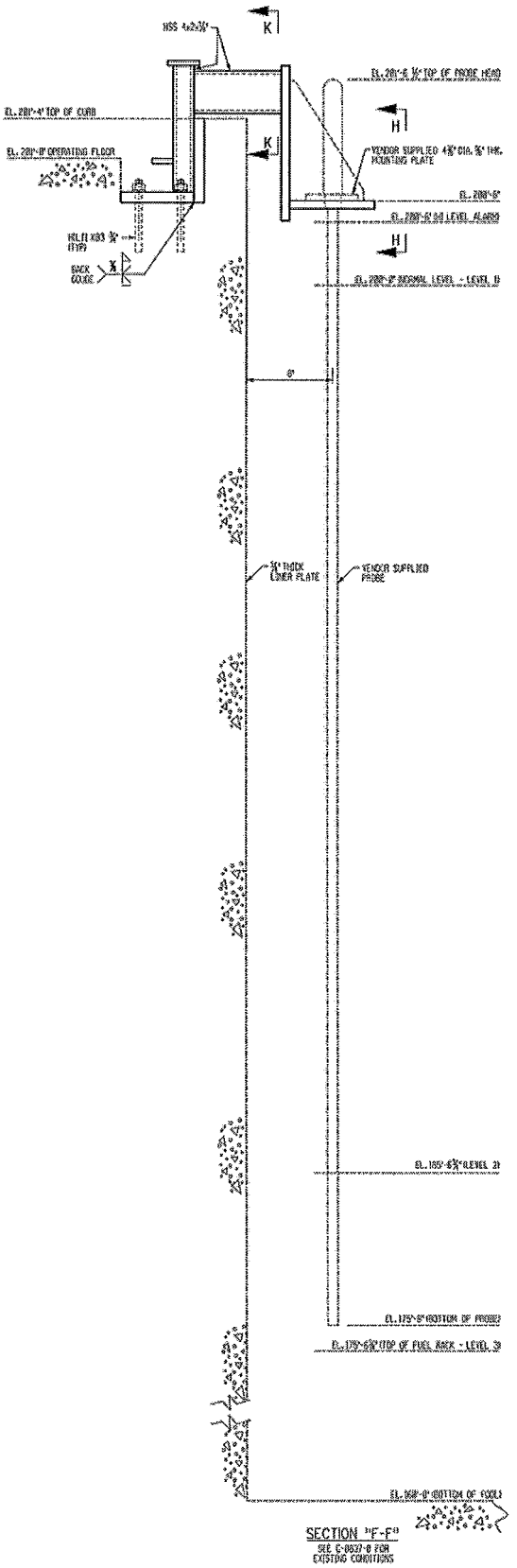
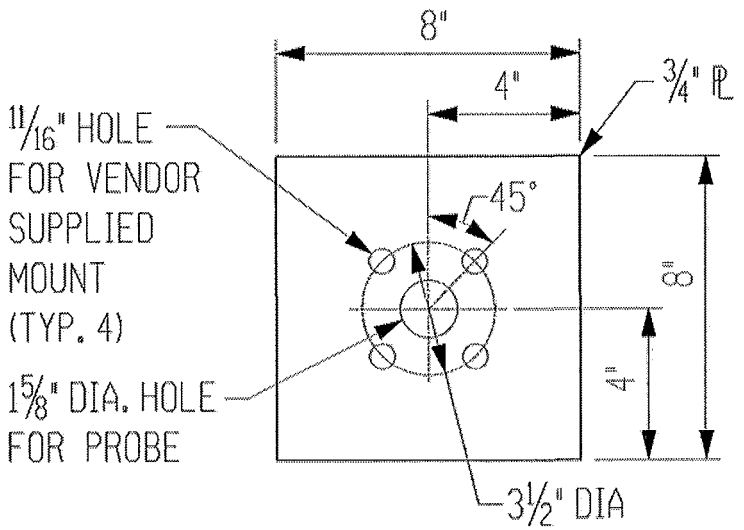

HSS 4x2x3/8"
K
EL. 201'-6 3/4" TOP OF PROBE HEAD
EL. 201'-4" TOP OF CURB
H
EL. 201'-0" OPERATING FLOOR
K
VENDOR SUPPLIED 4 3/8" DIA. 3/4" THK. MOUNTING PLATE
EL. 200'-6"
EL. 200'-6 3/4 LEVEL ALARM
H
HILTI KB3 3/8" (TYP)
BACK GOUGE
K
EL. 200'-0" NORMAL LEVEL - LEVEL 0
0"
1" THICK LOWER PLATE
VENDOR SUPPLIED PROBE
EL. 185'-6 3/4" LEVEL 2
EL. 179'-6" BOTTOM OF PROBE
EL. 179'-6" TOP OF FUEL RACK - LEVEL 3
EL. 168'-0" BOTTOM OF POOL
SECTION "F-F"
SEE C-0621-0 FOR EXISTING CONDITIONS

Figure 1b




MOUNTING PLATE DETAIL

Figure 2

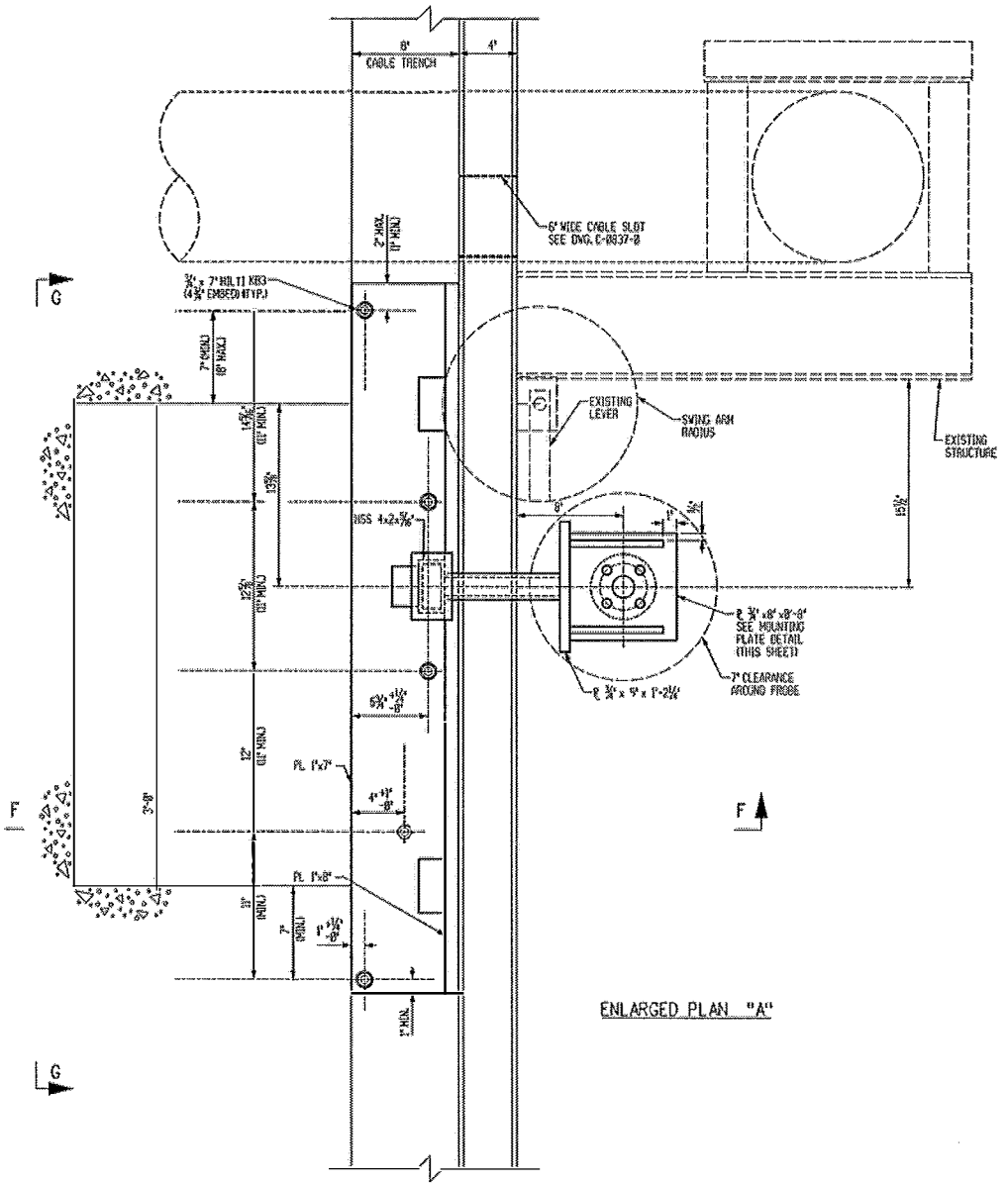

8"
CABLE TRENCH
4"
6" WIDE CABLE SLOT
SEE DWG. C-0837-8
EXISTING
LEVER
SWING ARM
RADIUS
EXISTING
STRUCTURE
7" CLEARANCE
AROUND FRAME
ENLARGED PLAN "A"

Figure 3

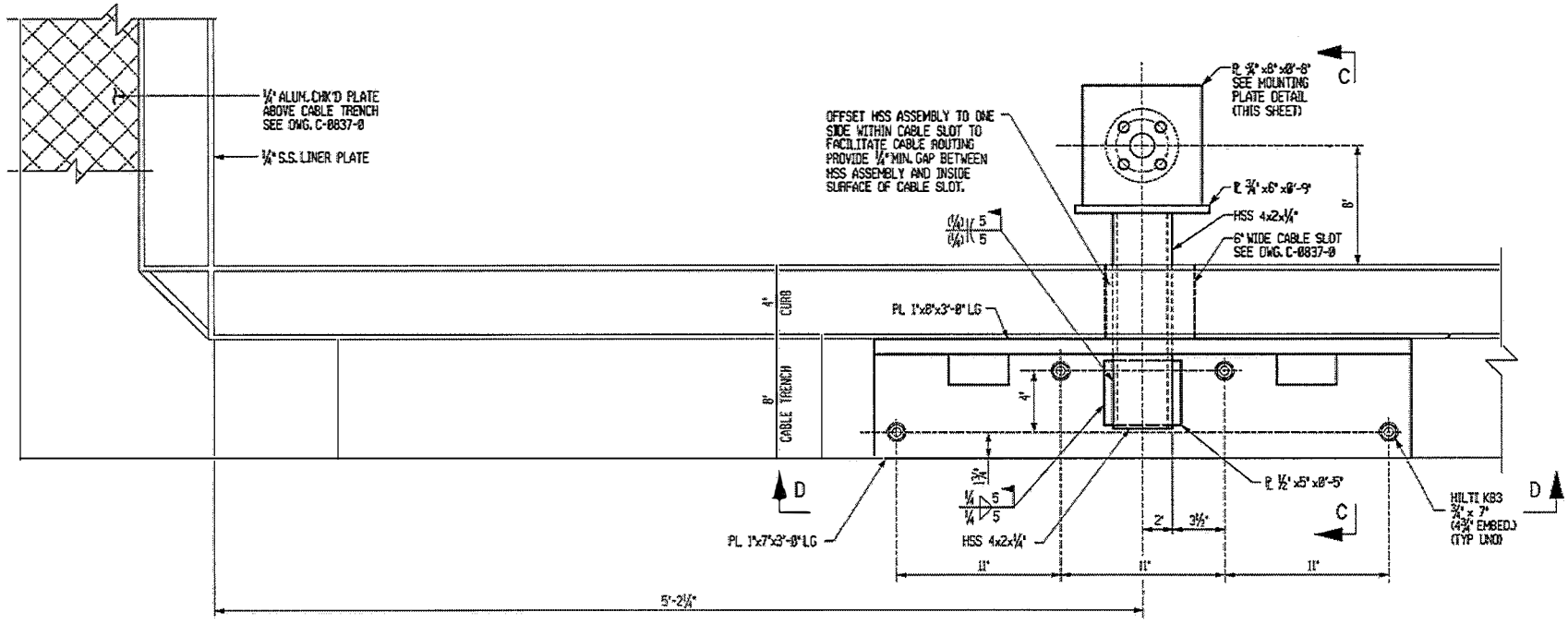

¼" ALUM. CHK'D PLATE
ABOVE CABLE TRENCH
SEE DWG. C-0837-0
¼" S.S. LINER PLATE
OFFSET HSS ASSEMBLY TO ONE
SIDE WITHIN CABLE SLOT TO
FACILITATE CABLE ROUTING
PROVIDE ¼" MIN. GAP BETWEEN
HSS ASSEMBLY AND INSIDE
SURFACE OF CABLE SLOT.
PL ¾" x8" x8'-8"
SEE MOUNTING
PLATE DETAIL
(THIS SHEET)
PL ¾" x6" x8'-9"
HSS 4x2x¼"
6" WIDE CABLE SLOT
SEE DWG. C-0837-0
8'
4" CURB
8" CABLE TRENCH
PL 1"x8"x3'-8" LG
4"
2¾"
PL 1"x7"x3'-8" LG
HSS 4x2x¼"
PL ½" x5" x8'-5"
HILTI KB3
¾" x 7"
(4¾" EMBED.)
(TYP UNO)
2"
3½"
11"
11"
11"
5'-2¼"
C
D
ENLARGED PLAN "B"

Figure 4

**RAI #2**

For RAI 1 (a) above, please provide the results of the analyses used to verify the design criteria and methodology for seismic testing of the SFP instrumentation and the electronics units, including, design basis maximum seismic loads and the hydrodynamic loads that could result from pool sloshing or other effects that could accompany such seismic forces.

**PSEG Response to RAI #2**

The SFPLI probe assembly has been shown to meet IEEE 344-2004 by analysis and testing. Because the probe dimensions preclude testing in a typical test apparatus, analysis is the primary method of qualification. Physical impact testing was performed to demonstrate that impact of the probe on the SFP liner would not adversely affect the integrity of the SFP liner or the probe. The results of the analysis and testing are provided by the MOHR SFP-1 level probe assembly seismic analysis report (Reference 4), which shows that the level probe assembly meets the requirements of NRC Interim Staff Guidance JLD-ISG-2012-03 (Reference 5) and IEEE 344-2004 requirements for adequacy of seismic design and installation for SFPLI with consideration of seismic and hydrodynamic effects.

The analysis performed in Reference 4 utilized an ANSYS finite element model to dynamically analyze the response of the probe to seismic loads and to determine the loads that will be transmitted to the probe mounting. MOHR performed structural evaluations using HCGS-specific design criteria and configuration, including seismic acceleration time history excitation that bounds the HCGS safe shutdown earthquake (Reference 6). Reference 6 confirmed that the plant-specific configuration meets JLD-ISG-2012-03 and IEEE 344-2004 requirements and that the reaction forces and moments transmitted to the mounting bracket remain bounded for the HCGS design.

PSEG calculation 6H4-4074 (Reference 7) shows the structural adequacy of the mounting bracket considering hydrodynamic and seismic loads applicable to the probe and submerged components of the mounting support structure at the installed location. Reference 7 establishes Seismic II/I qualification for the mounting, consistent with the Seismic Category I classification of the SFP and the augmented quality classification of the SFPLI. Based on the HCGS design criteria (Reference 2), the Seismic II/I allowable stresses and loading combinations that account for safe shutdown earthquake loads are the same as those used for Seismic Category I design. The anchor bolts that attach the mounting structures to the refuel floor are safety-related, Seismic Category I.

The electronics and battery packages have been tested to Seismic Category I requirements to meet IEEE 344-2004. The spectra used for this testing are substantially greater than the spectra for the HCGS Lower Control Equipment

Room where these packages are installed. The test results are presented in the MOHR EFP-IL SFPI system seismic test report (Reference 8).

**RAI #3**

For each of the mounting attachments required to attach SFP level equipment to plant structures, please describe the design inputs, and the methodology that was used to qualify the structural integrity of the affected structures/equipment.

**PSEG Response to RAI #3**

The design inputs and methodology for structural integrity of the level probe mounting attachments are described in Reference 7. Design inputs include site-specific seismic and hydrodynamic loads.

The electronics and battery packages have been tested to Seismic Category I requirements in accordance with IEEE 344-2004. The spectra used for this testing are substantially greater than the spectra for the Lower Control Equipment Room where these packages are installed. The test results are presented in the MOHR SFPI system seismic test report (Reference 8). The electronics, power supply, and battery boxes are mounted using HCGS standard support designs, and all conduits are attached to standard HCGS supports (Reference 9) to ensure structural adequacy.

**Section 3.6 Design Features: Qualifications**

*3.6.2 Qualification and Reliability*

**Background to RAI #4**

The ISE states, in part,

> The NRC staff notes that further information regarding qualification and reliability of the SFP level instrumentation is not currently available for review. In its letter dated August 20, 2013, the licensee indicated that the information will be provided to the staff in the August 2014, six-month OIP update. The staff has identified these requests as:

**RAI #4**

Please provide the following:

a) A description of the specific method or combination of methods that will be applied to demonstrate the reliability of the permanently installed equipment under BDB ambient temperature, humidity, shock, vibration, and radiation conditions.

b) A description of the testing and/or analyses that will be conducted to provide assurance that the equipment will perform reliably under the worst-case credible design basis loading at the location where the equipment will be mounted. Include a discussion of this seismic reliability demonstration as it applies to a) the level sensor mounted in the SFP area, and b) any control boxes, electronics, or read-out and retransmitting devices that will be employed to convey the level information from the level sensor to the plant operators or emergency responders.

c) A description of the specific method or combination of methods that will be used to confirm the reliability of the permanently installed equipment such that following a seismic event the instrument will maintain its required accuracy.

*(This information* was *previously requested* as *RAI-4 in NRC letter dated July* 22, *2013)*

**PSEG Response to RAI #4**

a) Section 3.4 of Nuclear Energy Institute (NEI) 12-02 (Reference 10) includes criteria to consider the effects of temperature, humidity, and radiation in the vicinity of the SFP and the area of use, for either a minimum of seven days or until off-site resources can be deployed by the diverse and flexible (FLEX) mitigating strategies in accordance with NRC Order EA-12-049. For the purposes of evaluating SFPLI environmental conditions, PSEG assumes 72 hours as the time for off-site resource deployment following a beyond-design-basis (BDB) event, based on the HCGS mitigating strategies including participation in the Strategic Alliance for FLEX Emergency Response (SAFER). HCGS implementation of FLEX strategies is deferred beyond the NRC Order EA-12-051 compliance date via schedule relaxation approved by NRC in Reference 11. Therefore, PSEG evaluated environmental conditions for a seven-day period (Reference 12) in order to address SFP level instrumentation (SFPLI) operation without FLEX implementation, consistent with NEI 12-02 Section 3.4. Shock and vibration are also addressed in accordance with NEI 12-02 criteria.

*Temperature and Humidity - Probe Assembly*

The MOHR SFP-1 level probe assembly materials qualification report (Reference 13) demonstrates SFPLI capability for SFP environmental conditions including seven-day BDB conditions of 212°F and 100% relative humidity in the SFP area. In the HCGS evaluation of a seven-day ELAP without FLEX implementation (Reference 12), PSEG

evaluated conditions exceeding 212°F with SFP boiling, which is considered to be an extremely unlikely scenario given current plant design and mitigation capabilities. Probe assembly material qualification temperatures in the MOHR report (Reference 13) are greater than 212°F and bound postulated temperatures in the vicinity of SFP during either a 72-hour ELAP with FLEX or a seven-day ELAP without FLEX implementation.

*Temperature and Humidity - Electronics*

The electronic equipment is mounted within the Lower Control Room Equipment Room, which is classified as a mild environment in accordance with HCGS environmental design criteria document D7.5 (Reference 14), with a maximum temperature of 85°F and maximum relative humidity of 90% under design basis conditions. The maximum temperatures for a BDB extended loss of ac power (ELAP) at HCGS assuming implementation of FLEX are calculated utilizing the GOTHIC computational code and documented in Vendor Technical Document (VTD) 432340 (Reference 15). The maximum expected ambient temperature in the room where the electronics will be located is not expected to exceed 115°F during a 72-hour ELAP event assuming FLEX equipment heat loads, based on the GOTHIC analyses which show calculated temperatures between 105°F and 114°F.

During a seven-day ELAP scenario without FLEX implementation, the heat loads in the Lower Control Equipment Room would be reduced and Station Blackout (SBO) coping actions would be taken, e.g., to establish passive ventilation by opening doors. Therefore, a seven-day ELAP without FLEX is not expected to result in higher temperatures than those calculated for the 72-hour FLEX scenario in the Lower Control Equipment Room.

The temperature and humidity test values used in the MOHR EFP-IL SFPI system test report (Reference 16) demonstrate reliable operation of the SFPLI electronics under BDB temperature and humidity conditions during either a 72-hour ELAP with FLEX or a seven-day ELAP without FLEX implementation.

*Radiation – Probe Assembly*

A radiation dose rate analysis was performed to support the radiological assessment requirements defined by NEI 12-02 for the SFP area (Reference 17). The results of the analysis provided dose rates and integrated doses for seven days post-event with SFP water level at NEI 12-02 Level 3 (i.e., top of fuel racks). The analysis also provided dose rates and integrated doses for 40-year normal

operation. The seven-day integrated doses were based on the 100-hour old shutdown core inventories (spent fuel sources) as defined in NEI 12-02. The results from the dose rate analysis (dose rate and total integrated dose) were used as the design criteria supplied to MOHR as part of the PSEG detailed specification (Reference 18). The MOHR SFP-1 level probe assembly materials qualification report (Reference 13) is used as the basis to demonstrate reliability of the permanently installed equipment located in the SFP and surrounding area under the BDB radiation conditions.

*Radiation - Electronics*

The SFPLI electronic equipment is located in the Lower Control Equipment Room, which is a mild environment located below the Main Control Room (MCR) and below the elevation of the operating deck in the fuel handling area. The maximum post-event dose rates and integrated doses for HCGS design basis accidents are assumed to bound any BDB post-event radiation levels (dose rate and total integrated dose) due to the inherent shielding provided from the structures (concrete floors and walls) between the Reactor Building and the Auxiliary Building. The SFPLI electronics utilize commercial-off-the-shelf components containing Complementary Metal Oxide Semiconductor (CMOS) devices which have been found to be capable of withstanding ionizing radiation dose of up to 1,000 rad as described in EPRI 1021067 “Nuclear Power Plant Equipment Qualification Reference Manual” Rev 1, and discussed in NRC Regulatory Guide 1.209 “Guidelines for Environmental Qualification of Safety-Related Computer Based Instrumentation and Control Systems in Nuclear Power Plants.” The limit of 1,000 rad is bounding for a mild environment such as the Lower Control Equipment Room and is used as the basis to demonstrate reliability of the permanently installed electronic equipment.

*Shock and Vibration – Probe Assembly and Electronics*

Shock and vibration test results are provided in vendor test reports. The MOHR shock and vibration test reports for the SFP-1 level probe assembly (Reference 19) and EFP-IL SFPI system (Reference 20) meet NEI 12-02 criteria for documentation of resistance of the SFPLI to non-seismic mechanical shock and vibration loading.

b) In order to support seismic qualification of the SFPLI in accordance with NRC Order EA-12-051 requirements and NEI 12-02 criteria, composite seismic Required Response Spectra (RRS) enveloping several nuclear generating stations were developed for use by MOHR. The composite RRS are significantly higher than HCGS RRS as

specified in the procurement specification for SFPLI (Reference 18). MOHR used seismic acceleration time history excitations that bound the composite RRS to demonstrate qualification of the level probe assembly in the seismic analysis report (Reference 4). Reference 4 documents the seismic adequacy of the probe assembly under seismic and hydrodynamic conditions by analysis. This report also documents testing to demonstrate that potential probe contact with the SFP liner would have no adverse effect on either the SFPLI or the SFP liner.

MOHR performed structural evaluations using HCGS-specific design criteria and configuration, including seismic acceleration time history excitation that bounds the HCGS safe shutdown earthquake RRS (Reference 6). This HCGS-specific analysis shows that the maximum stresses in the probe are significantly lower than the probe material yield stress.

Calculation 6H4-4074 (Reference 7) documents the structural adequacy of the probe mounting bracket. The analysis demonstrates that the probe bracket is adequate to withstand the postulated seismic and hydrodynamic forces for the specific HCGS configuration.

The MOHR SFPI system seismic test report (Reference 8) documents testing performed for the EFP-IL Signal Processor. The test verified that the Signal Processor continued to function after being subjected to the required seismic response spectra, proving adequacy of seismic design.

c) The MOHR EFP-IL SFPI system uncertainty analysis report (Reference 21) documents that the SFPLI accuracy is not expected to be significantly affected by seismic or hydrodynamic loading based on the SFPLI components meeting IEEE-344-2004 criteria.

**Background to RAI #5**

The ISE states, in part,

> In addition, the staff plans to verify the results of the licensee's testing and analysis used to demonstrate the qualification and reliability of the installed equipment when it is completed based on the licensee's response to the following RAI.

**RAI #5**

For RAI 4 above, please provide the results from the selected methods, tests and analyses used to demonstrate the qualification and reliability of the installed equipment in accordance with the Order requirements.

**PSEG Response to RAI #5**

The results of the activities performed to demonstrate the qualification and reliability of the installed equipment are referenced in the response to RAI #4.

**Section 3.7 Design Features: Independence**

**Background to RAI #6**

The ISE states, in part,

> The NRC staff notes that with this arrangement, the loss of one primary or backup power supply will not affect the operation of the independent channel under BDB event conditions. The implementation of such design provisions appears to be consistent with NEI 12-02, as endorsed by the ISG, and the electrical functional performance of each level measurement channel would be considered independent of the other channel. However, the NRC staff plans to verify the final electrical power supply design information when it is provided. The NRC staff has identified this request as:

**RAI #6**

Please provide the NRC staff with the final configuration of the power supply source for each channel so that the staff may conclude that the two channels are independent from a power supply assignment perspective.

**PSEG Response to RAI #6**

Each channel is provided with power from separate Class 1E power supplies (channel A and channel B) using separate fuse panels (1YF401 and 1YF402). Power is supplied to the fuse panels via 120 VAC vital inverters (1AD481 and 1BD481). Upon loss of 120 VAC, the inverters are supplied power from separate Class 1E 125 VDC station batteries.

**Section 3.8 Design Features: Power Supplies**

**Background to RAI #7**

The ISE states, in part,

> The NRC staff notes that the proposed criteria for the AC power sources and the sizing of the battery backup appears to be consistent with NEI 12-02, as endorsed by the ISG. However, the staff plans to evaluate the AC source in more detail and to verify the results of the licensee's calculation for required duty cycle given the final design load of the instrument channel for its installed configuration. The staff has identified this request as:

**RAI #7**

Please provide final design information for the power supply for the SFP level instrumentation and the results of the calculation depicting the battery backup duty cycle requirements demonstrating that its capacity is sufficient to maintain the level indication function until offsite resource availability is reasonably assured.

*(This information* was *previously requested* as *RAI-6 in NRC letter dated July* 22, *2013. However based on feedback from the licensees, it was revised as above)*

**PSEG Response to RAI #7**

The MOHR EFP-IL SFPI system provides at least seven-day battery life assuming typical use and accounting for postulated post-event environmental conditions. Battery life of at least seven days is achieved using average sample rates of 30 samples per hour. Details of the system battery life and duty cycle are provided in the MOHR battery life report (Reference 22).

**Section 3.9 Design Features: Accuracy**

**Background to RAI #8**

The ISE states, in part,

> The NRC staff notes that the estimated instrument channel design accuracies and methodology appear to be sufficient to maintain the instrument channels to within their designed accuracies before significant drift can occur. The staff plans to verify that the licensee's proposed instrument performance is consistent with these estimated accuracy values. Further, the NRC staff plans to verify that the channels will retain these accuracy performance values following a loss of power and subsequent restoration of power. The staff has identified this request as:

**RAI #8**

Please provide analysis verifying that the proposed instrument performance is consistent with these estimated accuracy normal and BDB values. Please demonstrate that the channels will retain these accuracy performance values following a loss of power and subsequent restoration of power.

**PSEG Response to RAI #8**

The MOHR EFP-IL SFP system uncertainty analysis (Reference 21) shows that the SFPLI exceeds the water level measurement accuracy requirements of NEI 12-02. Power interruption testing has been performed on the MOHR EFP-IL signal processor and back-up battery power source. Test results indicate that no deficits were identified with respect to maintenance of reliable function, accuracy, or calibration as a result of power interruption. The results of testing provided evidence of reliable transition from the normal AC power source to back-up battery without affecting accuracy or calibration. The results of the tests are provided in the MOHR EFP-IL SFPI system power interruption report (Reference 23).

**Section 3.10 Design Features: Testing**

**Background to RAI #9**

The ISE states, in part,

> The NRC staff notes that further information regarding the design of the SFP level instrumentation to provide for routine testing and calibration is not currently available for review. In its letter dated August 20, 2013, the licensee indicated that the information will be provided to the staff in the August 2014, six-month OIP update. The staff has identified this request as:

**RAI #9**

Please provide the following:

a) A description of the capability and provisions the proposed level sensing equipment will have to enable periodic testing and calibration, including how this capability enables the equipment to be tested in-situ.

b) A description of the calibration tests and functional checks that will be performed and the frequency at which they will be conducted. Discuss how these surveillances will be incorporated into the plant surveillance program.

c) A description of the preventive maintenance tasks required to be performed during normal operation, and the planned maximum surveillance interval that is necessary to ensure that the channels are fully conditioned to accurately and reliably perform their functions when needed.

*(This information* was *previously requested* as *RAI-8 in NRC letter dated July* 22, *2013)*

**PSEG Response to RAI #9**

a) Calibration can be accomplished using time domain reflectometry (TDR) to demonstrate the impedance waveform through the transmission cable and connectors from the installed signal processor to the probe are unchanged when compared with as installed configuration. During normal operation, the level instrument automatically monitors the integrity of its level measurement system. All testing can be performed using in-situ capability.

b) Channel checks are performed by comparing the level measurements displayed by the primary and backup channels directly to each other as part of routine operator rounds in accordance with HCGS Operations procedures. Level alarms from plant instrumentation provide an additional means of checking SFPLI readings (i.e., when no alarm condition exists and the SFPLI channels are providing normal level readings). The channel checks are currently performed on a weekly basis.

The MOHR operator's manual, technical manual for the signal processor, and technical manual for the probe assembly (References 24, 25, and 26, respectively) provide testing and calibration procedures for the SFPLI. The vendor guidance was used to determine maintenance and test activities in accordance with the HCGS Preventive Maintenance (PM) process. These activities and their frequency are described in response to RAI #9c.

c) The following maintenance activities and frequencies have been identified for the SFPLI:

Six-month diagnostics tests:

- Memory test
- Battery test
- Temperature compensation test
- Scan test and export logs

2-year activities:

- Battery replacement
- Memory card replacement
- Transmitter calibration checks (TDR calibration check, probe and transmission cable health checks)
- Clock calibration
- Visual inspection of repairable head

These activities have been identified using the PM process and vendor recommendations, and are subject to change using PSEG's administrative controls.

**Section 3.11 Design Features: Display**

**Background to RAI #10**

The ISE states, in part,

> The NRC staff notes that further information regarding the accessibility, habitability, resource availability and communications with decision-makers as it relates to the location for the SFP level instrumentation displays is not currently available for review. In its letter dated August 20, 2013, the licensee indicated that the information will be provided to the staff in the August 2014, six-month OIP update. The staff has identified this request as:

**RAI #10**

For any SFP level instrumentation displays located outside the main control room, please describe the evaluation used to validate that the display location can be accessed without unreasonable delay following a BDB event. Include the time available for personnel to access the display as credited in the evaluation, as well as the actual time (e.g., based on walk-throughs) that it will take for personnel to access the display. Additionally, please include a description of the radiological and environmental conditions on the paths personnel might take. Describe whether the display location remains habitable for radiological, heat and humidity, and other environmental conditions following a BDB event. Describe whether personnel are continuously stationed at the display or monitor the display periodically.

**PSEG Response to RAI #10**

The primary and back-up instrument channel displays are in the Lower Control Equipment Room which is located two levels below the Main Control Room (MCR) and is easily accessible. The displays can be promptly accessed and viewed by emergency response staff using a stairwell located immediately outside the MCR. The Lower Control Equipment Room is a mild environment for postulated design basis accident (DBA) conditions as stated in HCGS environmental design criteria document D7.5 (Reference 14). The maximum post-DBA dose rates and integrated doses for HCGS design basis accidents are assumed to bound any BDB post-event radiation levels (dose rate and total integrated dose) due to the inherent shielding provided from the structures (concrete floors and walls) between the Reactor Building and the Auxiliary Building. The estimated doses obtained from SFP drain down conditions at NEI 12-02 Level 3 (top of fuel rack) and exposure to personnel monitoring SFP levels in the Lower Control Equipment Room are bounded by the DBA radiological conditions. Temperature and humidity have been evaluated for this location

using GOTHIC analysis (References 12 and 15) and will not preclude access during BDB ELAP events.

Travel time from the MCR to the level displays is approximately 5 minutes based on an informal walk through via accessible paths within the Auxiliary Building. The display location was also selected due to its proximity to other equipment that would require manual operation or require operator actions in support of BDB mitigating strategies implementation. The location of the displays facilitates communication among emergency response personnel and the SFPLI design can accommodate either periodic or continuous monitoring based on the requirements of the BDB mitigating strategy.

**Section 3.13 Programmatic Controls: Procedures**

**Background to RAI #11**

The ISE states, in part,

> The NRC staff notes that further information regarding the licensee's plan to establish and maintain procedures for the testing, calibration, and use of the primary and backup SFP pool instrument channels is not currently available for review. In its letter dated August 20, 2013, the licensee indicated that the information will be provided to the staff in the August 2014, six-month OIP update. The staff has identified this request as:

**RAI #11**

Please provide a list of the procedures addressing operation (both normal and abnormal response), calibration, test, maintenance, and inspection that will be developed for use of the spent SFP instrumentation. The licensee is requested to include a brief description of the specific technical objectives to be achieved within each procedure.

**PSEG Response to RAI #11**

The HCGS SFPLI has been installed using PSEG's design change process and is subject to PSEG procedures and processes to address operation (both normal and abnormal response), calibration, test, maintenance, and inspection. The specific technical objectives are addressed as follows:

1) Operation (Both Normal and Abnormal Response)

The HCGS Operations log for the Auxiliary Building (Reference 27) has been revised to include weekly checks of the primary and backup displays in the Lower Control Equipment Room. The log readings check for SFP water level to be

consistent with normal operation, establish a maximum deviation of 0.5 ft. between channels, and initiate corrective actions for unsatisfactory readings.

For operator response to abnormal conditions, the HCGS alarm response procedure for SFP level alarms (Reference 28) has been revised to provide direction to the operator to check SFP level using the SFPLI displays in the Main Control Room or the Lower Control Equipment Room. Guidelines for implementing NRC Order EA-02-026 Section B.5.b mitigating strategies (References 29, 30, and 31) have been revised to include a precaution against using radios in the vicinity of the SFP to avoid potentially adverse effects of electromagnetic interference (EMI) on the SFPLI.

2) Calibration

PSEG has vendor documents (References 24, 25, and 26) that include guidance for preventive and corrective maintenance of the SFPLI. The SFPLI is included in the PSEG PM process, which includes instrument calibration based on vendor recommendations.

3) Test

Testing of the SFPLI electronics and batteries are included in the SFPLI PM process.

4) Maintenance

PM process administrative controls are applicable to the HCGS SFPLI. PM activities include testing, calibration, replacement (e.g., batteries and memory cards) and visual inspection of the probe and head. Administrative controls on SFPLI availability are addressed in Reference 32.

Corrective maintenance administrative controls are also applicable to the HCGS SFPLI. This includes administrative controls developed to determine corrective actions and compensatory measures to address the unavailability of SFPLI and FLEX equipment.

5) Inspection

SFPLI inspections of the sensor probe tube and repairable head are part of the PM process. Vendor documents include guidance for performing inspections as PM activities or as needed to support corrective maintenance.

**Section 3.14 Programmatic Controls: Testing and Calibration**

**Background to RAI #12 and #13**

The ISE states, in part,

> The NRC staff notes that further information regarding the testing, calibration and compensatory actions for the SFP level instrumentation is not currently available for review. In its letter dated August 20, 2013, the licensee indicated that the information will be provided to the staff in the August 2014, six-month OIP update. The staff has identified these requests as:

**RAI #12**

Please provide the following:

a) Further information describing the maintenance and testing program the licensee will establish and implement to ensure that regular testing and calibration is performed and verified by inspection and audit to demonstrate conformance with design and system readiness requirements. Include a description of your plans for ensuring that necessary channel checks, functional tests, periodic calibration, and maintenance will be conducted for the level measurement system and its supporting equipment.

b) A description of PSEG's plans for implementing the guidance in NEI 12-02, Section 4.3 regarding compensatory actions for one or both nonfunctioning channels.

c) A description of the compensatory actions to be taken in the event that one of the instrument channels cannot be restored to functional status within 90 days.

*(This information* was *previously requested* as *RAI-11 in NRC letter dated July* 22, *2013)*

**PSEG Response to RAI #12**

a) The requested information is provided in response to RAI #9.

b) Provisions associated with out of service or inoperable equipment including out of service times and compensatory actions in accordance with NEI 12-02 Section 4.3, “Testing and Calibration,” are incorporated into Operations procedure guidance for equipment control (Reference 32).

c) Both the primary and backup SFPLI channels incorporate permanently installed equipment with no reliance on portable equipment or post-event installation requirements. The equipment is relatively simple and robust, and is provided under augmented quality requirements. The design and permanent installation coupled with vendor support and spare parts reasonably diminish the likelihood of a single channel being out of service greater than 90 days, and greatly reduce the likelihood that both channels would be out of service for an extended period of time.

   Provisions associated with out of service or inoperable equipment including out of service times and compensatory actions are incorporated in HCGS Operations procedure guidance (Reference 32) in accordance with NEI 12-02 Section 4.3, "Testing and Calibration." Specific compensatory measures and corrective actions would depend on the circumstances associated with the equipment unavailability and would include vendor support and corrective maintenance (including equipment replacement) as appropriate.

**RAI #13**

Please provide a description of the in-situ calibration process at the SFP location that will result in the channel calibration being maintained at its design accuracy.

**PSEG Response to RAI #13**

The requested information is provided in response to RAI #9.

**References**

1) PSEG Specification G-0051(Q), “Category 1 Structures, Floor Response Spectra for Seismic Analysis of Equipment and Components for Hope Creek Generating Station”

2) PSEG Document 10855-D2.1 – “General Civil-Structural Design Criteria for Hope Creek Generating Station”

3) IEEE 344-2004 – “Recommended Practice for Seismic Qualification of Class 1E Equipment for Nuclear Power Generating Stations”

4) Vendor Technical Document (VTD) 432306 Volume 19, 1-0410-9 – “MOHR SFP-1 Level Probe Assembly Seismic Analysis Report” (PSEG Calculation 6H4-4097)

5) NRC Interim Staff Guidance JLD-ISG-2012-03 Revision 1, “Industry Guidance for Compliance with NRC Order EA-12-051, “To Modify Licenses with Regard to Reliable Spent Fuel Pool Instrumentation’”

6) PSEG Calculation 6H4-4096, 1-0410-9.9 – “MOHR SFP-1 Site Specific Seismic Analysis Report: Hope Creek NGS (Hope Creek)”

7) 6H4-4074 – “Probe Mounting for Spent Fuel Pool Level Instrumentation Modification”

8) VTD 432306 Volume 10, 1-0410-6 – “MOHR EFP-IL SFPI System Seismic Test Report”

9) PSEG Drawing E-1406-0, “Raceway Notes, Symbols and Details”

10) NEI 12-02, "Industry Guidance for Compliance with NRC Order EA-12-051, 'To Modify Licenses with Regard to Reliable Spent Fuel Pool Instrumentation,"' Revision 1, dated August 2012

11) NRC Letter to PSEG, “Hope Creek Generating Station - Relaxation of the Schedule Requirements for Order EA-12-049, ‘Issuance of Order to Modify Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events’ (TAC NO. MF0867)”, dated April 29, 2015

12) PSEG Technical Evaluation 80113610-0112, “Temperature and Humidity in the SFP Area and Room 5302 With No FLEX Heat Loads”

13) VTD 432306 Volume 7, 1-0410-2 – “MOHR SFP-1 Level Probe Assembly Materials Qualification Report”

14) PSEG Document 10855-D7.5 – “Hope Creek Generating Station Environmental Design Criteria”

15) VTD 432340 - “Hope Creek Auxiliary Building Extended Loss of AC Power FLEX Response”

16) VTD 432306 Volume 6, 1-0410-1 – “MOHR EFP-IL SFPI System Temperature and Humidity Test Report”

17) VTD 432315 Volume 1, SL-012006 – "NEI 12-02 Spent Fuel Pool Doses"
18) PSEG Specification A-5-SF-EC-CDS-0517 - "Spent Fuel Pool Level Instrumentation Detailed Specification"
19) VTD 432306 Volume 17, 1-0410-16 – "MOHR SFP-1 Level Probe Assembly Shock and Vibration Test Report"
20) VTD 432306 Volume 9, 1-0410-5 – "MOHR EFP-IL SFPI System Shock and Vibration Test Report"
21) VTD 432306 Volume 18, 1-0410-15 - "MOHR EFP-IL SFPI System Uncertainty Analysis"
22) VTD 432306 Volume 11, 1-0410-7 – "MOHR EFP-IL SFPI System Battery Life Report"
23) VTD 432306 Volume 13, 1-0410-10 - "MOHR EFP-IL SFPI System Power Interruption Report"
24) VTD 432306 Volume 36, 1-0410-12 – "MOHR EFP-IL Signal Processor Operator's Manual"
25) VTD 432306 Volume 37, 1-0410-13 – "MOHR EFP-IL Signal Processor Technical Manual"
26) VTD 432306 Volume 38, 1-0410-14 – "MOHR SFP-1 Level Probe Assembly Technical Manual"
27) HC.OP-DL.ZZ-0006-F1, "HC-Auxiliary Building Log 6"
28) HC.OP-AR.ZZ-0013, "Overhead Annunciator Window Box D"
29) HC.OP-AM.TSC-0019, "Alternate Fuel Pool Make Up"
30) HC.OP-AM.TSC-0020, "Spent Fuel Pool - External Makeup"
31) HC.OP-AM.TSC-0021, "Spent Fuel Pool – External Spray"
32) OP-HC-108-115-1001, "Operability Assessment and Equipment Control Program"