UNITED STATES
NUCLEAR REGULATORY COMMISSION
REGION IV
1600 E. LAMAR BLVD.
ARLINGTON, TX 76011-4511

May 22, 2017

Mr. Thomas J. Palmisano
Vice President and Chief Nuclear Officer
Southern California Edison Company
San Onofre Nuclear Generating Station
P.O. Box 128
San Clemente, CA 92674-0128

SUBJECT: SAN ONOFRE NUCLEAR GENERATING STATION – NRC INSPECTION REPORT 05000206/2016004, 05000361/2016004, 05000362/2016004, AND 07200041/2016002

Dear Mr. Palmisano:

This letter refers to the U.S. Nuclear Regulatory Commission's (NRC) inspections conducted at your San Onofre Nuclear Generating Station (SONGS), Units 1, 2 and 3, and the Independent Spent Fuel Storage Installation (ISFSI) facilities on July 5-7, 2016, August 29-30, 2016, October 10-12, 2016, and April 10-11, 2017. The enclosed inspection report documents the inspection results that were discussed with Mr. Lou Bosch, Plant Manager, and other members of your staff at a debrief meeting conducted on April 11, 2017, when the inspectors were on-site. A final exit meeting was conducted on May 18, 2017 with licensing and engineering staff after the NRC inspectors received the laboratory 28-day concrete compressive strength and density results for the first section of the ISFSI top pad.

The purpose of the inspections were to verify compliance with the with the requirements specified in the Holtec International HI-STORM UMAX Canister Storage Systems Certificate of Compliance (CoC) 1040 Technical Specifications, the Final Safety Analysis Report (FSAR), and regulations in Title 10 of the *Code of Federal Regulations* (CFR) Parts 20, 50, and 72. The inspection included an examination of activities conducted under your license as they relate to public health and safety. Within these areas, the inspection included a review of the ISFSI foundation subgrade, concrete mix design, inspection of the concrete batch plant, inspection of concrete forms, placement of the reinforcing steel, observations of concrete mixing, delivery, sampling, and placement for selected activities associated with the construction of the UMAX ISFSI. The inspection determined that SONGS's UMAX ISFSI construction was performed in compliance with the requirements of the Holtec CoC, FSAR, and the requirements and standards established by the American Concrete Institute (ACI) and the American Society for Testing and Materials (ASTM), as required by your general license with one exception.

Based on the results of this inspection, the NRC has determined that one Severity Level IV violation of NRC requirements occurred. The violation related to the licensee's failure to follow a procedure requirement to test the density of the Important to safety (ITS) grout that was placed under the Cavity Enclosure Containers. Because SONGS placed the issue into their corrective

action process, demonstrated the grout met the required density, the violation was non-repetitive, and the violation was not willful, the violation was treated as a Non-Cited Violation (NCV), consistent with Section 2.3.2 of the Enforcement Policy. The NCV is described in the subject inspection report. If you contest the violation or significance of the NCV, you should provide a response within 30 days of the date of this inspection report, with the basis for your denial, to the Nuclear Regulatory Commission, ATTN: Document Control Desk, Washington DC 20555-0001, with copies to: (1) the Regional Administrator, Region IV and (2) the Director, Office of Enforcement, United States Nuclear Regulatory Commission, Washington, DC 20555-0001.

In accordance with 10 CFR 2.390 of the NRC's "Agency Rules of Practice," a copy of this letter, its enclosure, and your response, if you choose to provide one, will be made available electronically for public inspection in the NRC Public Document Room or from the NRC's Agencywide Documents Access and Management System (ADAMS), accessible from the NRC Web site at http://www.nrc.gov/reading-rm/adams.html. To the extent possible, your response should not include any personal privacy or proprietary information so that it can be made available to the Public without redaction.

Should you have any questions concerning this inspection, please contact the undersigned at 817-200-1191 or Mr. Lee Brookhart at 817-200-1549.

Sincerely,

/RA/

Ray L. Kellar, P.E., Chief
Fuel Cycle and Decommissioning Branch
Division of Nuclear Materials Safety

Dockets: 50-206; 50-361; 50-362; and 72-41
Licenses: DPR-13, NPF-10; NPF-15

Enclosure:
Inspection Report
w/Attachment: Supplemental Information

cc: Distribution for SONGS
Mr. Mark Morgan, Acting Regulatory Affairs
Dr. Robert B. Weisenmiller, Chair
Mr. Lou Bosch, Plant Manager
Mr. W. Matthews III, Esquire
Mr. Gonzalo Perez, Branch Chief

U.S. NUCLEAR REGULATORY COMMISSION
REGION IV

Dockets:	05000206, 05000361, 05000362, and 07200041
Licenses:	DPR-13, NPF-10; NPF-15
Report Nos.:	50-206/2016004, 50-361/2016004, 50-362/2016004, AND 72-41/2016002
Licensee:	Southern California Edison Co. (SCE)
Facility:	San Onofre Nuclear Generating Station (SONGS) Independent Spent Fuel Storage Installation (ISFSI)
Location:	5000 S. Pacific Coast Hwy San Clemente, California
Dates:	July 5, 2016 through April 11, 2017
Inspectors:	Lee E. Brookhart, Senior Inspector Fuel Cycle and Decommissioning Branch
	Eric J. Simpson, Inspector Fuel Cycle and Decommissioning Branch
Approved By:	Ray L. Kellar, P.E., Chief Fuel Cycle and Decommissioning Branch Division of Nuclear Materials Safety

Enclosure

EXECUTIVE SUMMARY

San Onofre Nuclear Generating Station (SONGS)
NRC Inspection Report 05000206/2016004, 05000361/2016004,
05000362/2016004, AND 07200041/2016002

The U.S. Nuclear Regulatory Commission (NRC) conducted an inspection of the construction activities associated with SONGS's Holtec HI-STORM UMAX facility. SONGS's Independent Spent Fuel Storage Installation (ISFSI) includes the previously existing Advanced NUHOMS Horizontal Modular Storage System and the new Holtec HI-STORM UMAX Canister Storage System and are licensed under a general ISFSI license from the NRC. The licensee had elected to use the Holtec HI-STORM UMAX Canister Storage System, Certificate of Compliance (CoC) 1040 Amendment 2 (ML16341B100) and Final Safety Analysis Report (FSAR), Revision 3 (ML16193A339). The multi-purpose canisters (MPC-37) are designed to hold 37 spent fuel assemblies and will be used in the UMAX ISFSI. The UMAX constructed at SONGS has been designed to hold 75 spent fuel storage canisters.

The HI-STORM UMAX stores sealed MPCs containing spent fuel using an in-ground Vertical Ventilated Module (VVM). The UMAX VVM provides structural protection, cooling, and radiological shielding for the MPCs. The VVM consists of five primary components. The Support Foundation Pad (SFP) (a reinforced pad that serves as the bottom of the VVM), the Cavity Enclosure Containers (CECs) (the stainless steel enclosures that contain one MPC each), the Self-hardening Engineered Subgrade (SES) (the middle section surrounding the CECs), the ISFSI top pad (reinforced pad that provides shielding and a riding surface for the cask transporter), and the closure lid (which serves as the CEC lid and supplies the ventilation to the sealed canister).

The SFP is a reinforced concrete pad that is approximately 2,500 square feet and 33 inches in depth. On top of the SFP, 75 CECs were placed that are approximately 20 feet tall with an inside diameter of approximately 8 feet. The SES middle lateral space between each CEC was filled in with concrete that had a minimum compressive strength of 3,000 pounds per square inch (psi). The ISFSI top pad is a reinforced concrete pad with the same length and width dimensions as the SFP but with an approximate depth of 30 inches. The closure lids will be placed on each CEC once a sealed (welded) MPC has been placed inside.

The SFP was constructed in six sections. NRC inspectors observed the first section's concrete placement activities on July 6, 2016. On August 29 and 30, 2016, NRC inspectors observed placement activities for several CEC components. The NRC inspectors observed concrete placement of the SES fill layer that was placed around the CECs on October 12, 2016. The ISFSI top pad was constructed in four sections. NRC inspectors observed the concrete placement activities of the first section on April 11, 2017. During the various site visits and through in-office reviews the NRC inspectors reviewed design documentation, subgrade density results, and shear wave evaluations associated with the ground below the UMAX.

The SFP, SES, and ISFSI top pad were designed and constructed in accordance with American Concrete Institute (ACI) 318-05, "Building Code Requirements for Structural Concrete." The inspection included a review of the concrete mix design, concrete material requirements, reinforcing bar specifications, and the concrete batch plant facility. Direct observations were conducted of concrete mixing, placement, and sample testing of the various sections of the VVM. The inspection determined that SONGS's UMAX ISFSI construction was performed in compliance with the requirements contained in the Holtec UMAX CoC Technical Specifications,

FSAR, and the requirements and standards established by the American Concrete Institute (ACI) and the American Society for Testing and Materials (ASTM) with one exception as noted in Section 1.2 a.

On-Site Fabrication of Components and Construction of an ISFSI (60853)

- The subgrade and material that was beneath the completed ISFSI met the Holtec UMAX FSAR requirements for density and shear wave velocity. The 28 day concrete strength test reports confirmed that all sections of the UMAX ISFSI met the required concrete strength specified in the Holtec UMAX FSAR and design specifications. One violation of NRC regulations was identified associated with the licensee's failure to follow procedure steps to test the grout density that was placed below the CECs (Section 1.2.a).

- The rebar placement within both the SFP and the ISFSI top pad was constructed in accordance with Holtec UMAX FSAR and design specifications for the type of rebar used, spacing requirements, and minimum bend diameters. The rebar was placed within the forms to meet the minimum concrete cover requirements specified in the ACI standards to protect the rebar from corrosion. The yield and tensile strength test reports for the placed rebar were reviewed and found to meet the 60,000 pound per square inch (psi) minimum yield strength requirement specified in the Holtec UMAX FSAR (Section 1.2.b).

- The concrete mix used in the various sections of the Holtec UMAX met the design specification requirements in respect to slump, temperature, density, and water/cement ratio. Concrete mix ingredients met the applicable ASTM and ACI standards for type of cement, admixtures, and water (Section 1.2.c).

- The ready-mix concrete batch plant that was used to construct the SONGS UMAX ISFSI had been inspected by the licensee and reviewed by the NRC to meet the requirements of ASTM C94, "Standard Specification for Ready-Mixed Concrete." The processes used for concrete mixing and delivery followed the ASTM standards with respect to maximum mixing time, maximum/minimum drum revolutions, addition of admixtures at the job site, and measurement of materials (Section 1.2.d).

- Concrete forms were adequately constructed and prepared in accordance with ACI requirements, including wetting of surfaces, removal of debris, control of mortar leakage, form deflection, removal of standing water, and application of release agents (Section 1.2.e).

- The concrete used in the SFP, SES sections, and ISFSI top pad at SONGS met the applicable ACI requirements for placement rate, exclusion of foreign material, no segregation of the material, and no use of re-tempered or remixed concrete (Section 1.2.f).

- The ACI and ASTM standards for concrete sampling were met with respect to sampling locations, methods, frequencies, number of samples, and methods for molding and curing strength test cylinders. The field technicians responsible for sampling and making the concrete test cylinders were certified as ACI Grade I Field Testing Technicians (Section 1.2.g).

- The concrete placed at SONGS for the UMAX ISFSI was maintained in a moist condition and cured for seven days as required by ACI standards (Section 1.2.h).

Report Details

Summary of Facility Status

The SONGS ISFSI consists of two ISFSI designs located adjacent to each other. The Transnuclear, Inc. Nuclear Horizontal Modular Storage (NUHOMS) ISFSI contained 51 loaded concrete advanced horizontal storage modules (AHSMs) which housed stainless steel dry shielded canisters (DSCs). Spent fuel from all three reactors were stored at the NUHOMS ISFSI in 50 of the canisters. Greater-than-Class-C (GTCC) waste from the Unit 1 reactor decommissioning project was stored in one canister. There were a total of 63 AHSMs on the NUHOMS ISFSI pad. The twelve empty AHSMs will be available for storage of additional GTCC waste. The NUHOMS ISFSI pad consisted of two adjacent pad areas designed to hold the AHSMs. The pads were both 293 feet in length. The first pad area was 43 feet 6 inches wide and held 31 canisters. The second pad area was 60 feet 6 inches wide and was designed to hold 62 AHSMs in a double row, positioned back to back. The 63 AHSMs currently on the pad were designed for the 24PT1-DSC (Unit 1 fuel) and 24PT4-DSC (Unit 2/3 fuel) canisters, which hold a maximum of 24 spent fuel assemblies. The 24PT1-DSCs were loaded and maintained under Amendment 0 of CoC 72-1029 and the 24PT4-DSCs were loaded and maintained under Amendment 1 of the CoC 72-1029. Both systems were being maintained under FSAR Revision 5.

The Holtec UMAX ISFSI portion was designed to hold 75 canisters. The longest length of the UMAX is 231 feet and the widest area width is 102 feet. The SFP was constructed below grade at the 8.5’ Mean Lower Low Water (MLLW) elevation. The top of the ISFSI top pad was located at the 31.5’ MLLW elevation. Approximately half of the UMAX ISFSI was located below grade while the other half had excavated common fill that sloped up to the top of the ISFSI top pad. SONGS plans to begin spent fuel loading operations of the UMAX ISFSI in the fall of 2017.

1 On-Site Fabrication of Components and Construction of an ISFSI (60853)

1.1 Inspection Scope

A construction inspection of the UMAX ISFSI consisted of reviews for a broad range of topics, including a review of SONGS’s concrete placement activities, inspection of the concrete batch plant, review of rebar placement, observations of concrete sampling activities, quality assurance, corrective actions, concrete quality, and concrete curing activities. The UMAX ISFSI design reviews and construction activities were reviewed against the requirements specified in the Holtec UMAX CoC Technical Specifications, FSAR, and the requirements and standards established by the ACI and ASTM standards.

1.2 Observations and Findings

a. UMAX Design

The Holtec HI-STORM UMAX FSAR specified the design requirements of the ISFSI in Tables 2.3.2, “Design Data for HI-STORM UMAX ISFSI” and 2.3.10, “Design Data for HI-STORM UMAX Version MSE” (most severe earthquake). The tables included shear wave and density requirements for the soils adjacent to and beneath the ISFSI structure. The required minimum shear wave velocity for soils adjacent to the UMAX ISFSI

is 450 feet per second (ft/sec). The required minimum shear wave velocity for the soil directly beneath the UMAX is 485 ft/sec. Native soil conditions at SONGS were shown to exceed the minimum requirements. Geotechnical data collected at the site showed that the existing soil had shear wave velocities that ranged from 729 ft/sec at a depth of two feet to approximately 1650 ft/sec at a depth of 98 feet. The FSAR required that the depth averaged density of soils beneath the UMAX ISFSI to be nominally 120 pounds per cubic foot (pcf). The soil underneath the UMAX ISFSI is characterized in geotechnical reports as sand from the San Mateo Formation. The SONGS Unit 2 and 3 UFSAR shows that San Mateo Sand has a total unit weight of 130 pcf. This exceeded the nominal density required by the FSAR.

Holtec UMAX FSAR Tables 2.3.2 and 2.3.10 specified a nominal concrete strength of 4,500 psi at 28 days for the SFP and ISFSI top pad and a minimum strength of 3,000 psi for the self-hardening engineered subgrade (SES). NRC inspectors reviewed the 28 day concrete test results for the SFP, the SES, and the ISFSI top pad. Test results for the SFP ranged from 4,190 to 6,450 psi and averaged 5,640 psi. One test result fell below the specified nominal strength of 4,500 psi. However, since every arithmetic average of three consecutive strength tests exceeded 4,500 psi and no individual strength test fell below 4,000 psi, the concrete met the specified strength requirement of ACI 318-05, Section 5.6.3.3. NRC randomly sampled 33 test results for the SES concrete. The compressive strength results reviewed by NRC ranged from 3,990 to 5,120 psi, averaging 4,640 psi. Those results exceeded the 3,000 psi minimum compressive strength requirement for the SES section. The first section of the ISFSI top pad results reviewed by NRC ranged from 5530 to 5960 psi and averaged 5681 psi. Those results exceeded the HI-STORM UMAX FSAR 4,500 psi minimum compressive strength requirement without exceptions.

The Holtec UMAX FSAR also specified density requirements for SFP, SES, and ISFSI top pad. The SFP had a specified nominal dry density of 120 pcf. The ISFSI top pad was required to have a nominal dry density of 135 pcf. The SES section had a minimum depth averaged density requirement of 120 pcf. The density measurements for the SFP ranged from 143 to 147 pcf. The SES section test results reviewed by NRC showed that the subgrade concrete density ranged from 144 to 148 pcf. Concrete samples from the ISFSI top pad ranged from 146 to 149 pcf. All concrete density measurements were made in accordance with the requirements of ASTM C39, “Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens,” Section 9.3. The concrete for the UMAX ISFSI at SONGS met all of the density requirements specified in the Holtec HI-STORM UMAX FSAR.

SONGS placed flow-able Five Star Fluid 100 grout material under each of the 75 CECs for leveling and support purposes to ensure the CECs would not be buoyed or displaced during SES concrete placement activities. Holtec Procedure HSP-58, “CEC Base late Grouting,” Revision 3, Step 2.2 designated the grout as an Important to Safety component. HSP-58 Exhibit 9.1, “Grout Density and Compressive Strength Confirmation of Design Conformance Form,” required licensee to verify that the density and compressive strength of the grout met the density and strength requirements for the SFP. The SFP and grout were required to have a minimum nominal dry density of 120 pcf and minimum 28-day compressive strength of 4,500 psi per UMAX FSAR Table 2.3.2 and as amended by Holtec 72.48 Evaluation #1100, Revision 4.

The grout samples taken during the CEC grouting operations were tested for 28 day compressive strength in accordance with ASTM C109, "Standard Test Method for Compressive Strength of Hydraulic Cement Mortars." The average 28 day compressive strength for all samples ranged from 7,831 to 8,399 psi, well above the required minimum of 4,500 psi. However, the licensee identified that the laboratory used to test the grout samples taken during placement activities failed to test the grout samples for density and had only tested the samples for compressive strength.

Title 10 CFR 72.150 requires, in part, that the licensee shall prescribe activities affecting quality by documented instructions, procedures, or drawings of a type appropriate to the circumstances and shall require that these instructions, procedures, and drawings be followed. The instructions, procedures, and drawings must include appropriate quantitative or qualitative acceptance criteria for determining that important activities have been satisfactorily accomplished. Contrary to the above, from September 14-19, 2016, the licensee failed to ensure Procedure HSP-58, Exhibit 9.1, was followed and the appropriate qualitative acceptance criteria for the grout density testing had been satisfactorily accomplished.

SONGS placed the failure to test the grout samples for density into their Corrective Action Program (CAP) as Nuclear Notification (NN) 203394445 and 203394463. Holtec also placed the issue into their CAP as Field Condition Report (FCR) FCR-2464-CON-090. On September 9, 2016, and prior to field production placement of the grout, a trial mock-up slab was placed utilizing the same mixer and the same grout type (5-Star Fluid Grout) as was used in the production grouting operation in the field. The grout lot number used for the trial slab was Lot #1427001756 and was also one of the five lots later used during production. This existing mock-up was cored to obtain measurable samples that were sent to the testing laboratory to determine the grout's density. Additionally, the licensee used remaining grout from the same lots used in the CEC grout placements to produce additional grout samples which were mixed as directed by the manufacturer's recommendations and procedure requirements and were also sent to the testing laboratory to determine the grout's density. All grout samples' dry density was found to be between 124.7 to 127.6 pcf, which was above the minimum required of 120 pcf. Additionally, the licensee used the data collected from the subsequent grout testing to develop a best fit line graph to correlate the 28 day compressive strength to density. Using the best fit line equations, a series of plotted strengths and their projected densities was created that encompassed the minimum and maximum compressive strengths found during the CEC grout placement activities. Based on the subsequent sample data collected and the evaluation correlating compressive strength to density, the licensee was able to demonstrate that the grout placed during field operations under each CEC exceeded the 120 pcf minimum requirement.

The NRC determined that the licensee's failure to follow procedure HSP-58 to test the grout for the required density to be a Severity Level IV Violation of NRC regulations. Since licensee staff entered the issue into their CAP, was able to demonstrate the grout used in the field met the required minimum density requirements, the safety significance of the issue was determined to be low, and because the violation was not willful or repetitive, this violation was treated as a Non-Cited Violation (NCV), consistent with Section 2.3.2 of the NRC Enforcement Policy (NCV 072-041/1602-01).

b. Concrete Reinforcement

The Holtec HI-STORM UMAX FSAR required that any reinforcing steel bar (rebar) used in its construction to have a 60,000 psi minimum yield strength. The purchase specifications for the rebar used in the SFP and ISFSI top pad called for ASTM Grade 60 rebar. NRC inspectors verified during rebar inspections for the SFP and the ISFSI top pad that the structural rebar was marked as ASTM Grade 60 #11 bar. The NRC inspectors also reviewed certified mill test results (CMTRs) for the rebar that indicated both yield and tensile strengths exceeding the 60,000 and 90,000 minimum psi requirements, respectively, for ASTM Grade 60 rebar.

The spacing requirements for #11 rebar were specified in Holtec UMAX FSAR Table 2.3.2 as being at least 9 inches (each face, each direction). NRC inspectors visually verified for selected areas that the #11 rebar as installed in the SFP and ISFSI top pad were spaced such that it met the minimum required spacing.

ACI-318 Section 7.2 specified that the minimum bend diameter of #11 rebar to be eight times the bar's diameter or, roughly, 11.2 inches. NRC inspectors reviewed engineering drawings and verified that for selected areas the bends on the rebar installed in the SFP and ISFSI top pad did not exceed the minimum bend diameter specified in the ACI code.

The minimum clear concrete cover requirements for #11 rebar as stipulated by ACI-318 were met or exceeded by SONGS in its rebar placement in the Holtec UMAX ISFSI. The engineering drawings for rebar placement and pad dimensions showed a distance of clear cover between the SFP bottom rebar and the mud mat of 3 inches. The clear concrete cover on the outsides of the SFP rebar that would be in contact with soil were also shown to be 3 inches. The concrete cover between the top of the SFP rebar and SES concrete was 2 inches. Lastly the ISFSI top pad rebar had clear concrete cover on all sides of between 3 and 4 inches. NRC inspectors visually verified the clear cover distances between the forms and rebar and the rebar height above the subgrade prior to the initial concrete placements for both the SFP and the ISFSI top pad on selected areas. The rebar in the SONGS UMAX ISFSI met or exceeded the minimum concrete clear cover requirements of ACI-318 Sections 7.7.1(a) and 7.7.1(b).

NRC inspectors also inspected the condition of the rebar prior to the concrete placement. NRC observed that the rebar was clean with some light rusting, which was acceptable per the ACI code. There was no dirt, oil, grease, or other debris on any rebar observed prior to the concrete placement activities.

c. Concrete Quality

The Portland cement used for the UMAX ISFSI constructed at SONGS conformed to the ASTM C150 "Standard Specification for Portland Cement" standard and other design requirements. The Project Specification Section 03300 Step 2.1.A, required that the Portland cement shall conform to ASTM C150, Type II, and not contain more than 0.6 percent equivalent alkalis. Certification of Tests from Mitsubishi Cement Corporation provided the chemical assay results for the Portland cement provided to SONGS. The test results documented that the cement met the limits specified in ASTM C150 for Type II cement. The total alkali was tested to be 0.56 percent, below the maximum limit specified in the design specification.

Project Specification Section 03300, Steps 2.1 B specified that that fine and coarse aggregates shall conform to the requirements of ASTM C33, "Standard Specification for Concrete Aggregates." Sieve analysis testing results from SCST Engineering documented that the coarse and fine aggregates used for the UMAX project met the qualifications of ASTM C33. The Project Specification also required that the coarse aggregates be Size No. 56 or 57. NRC inspectors reviewed laboratory test results for the coarse and fine aggregates used in the concrete for the UMAX ISFSI construction at the SONGS site. The coarse aggregate used was Size No. 57 provided by Robertson's Ready Mix facility from quarry in El Cajon, CA.

Project Specification Section 03300, Step 2.1.C specified that the water used for concrete shall meet the requirements of ASTM C94 "Standard Specification for Ready-Mixed Concrete." or be potable (meets drinking standards) water. The San Clemente Robertson's Ready Mix batch plant's water source met drinking water standards as documented in a letter, dated November 20, 2015, from the City of San Clemente Utilities Operations Supervisor that certified the water provided to the facility was potable water, suitable for human consumption.

The concrete supplied for construction of the UMAX ISFSI met the water to cement ratio requirements of ACI 318 Section 4.2.2 requirements. Project Specification 03300, Step 2.3 A required that that the water to cement ratio shall not exceed 0.50, as required by the ACI code, for all sections of the UMAX ISFSI. The approved concrete mix designs for the SFP and ISFSI top pad specified the water to cement ratios to not exceed 0.40, the SES section was required not to exceed 0.50. NRC inspectors reviewed the batch tickets for concrete trucks which were sampled and many other trucks throughout the day during the SFP, SES, and ISFSI top pad pours that were observed by the inspectors. The water to cement ratios for those concrete trucks never exceeded the design specifications or ACI requirements.

d. Concrete Mixing and Delivery

The concrete for the UMAX ISFSI was mixed and delivered to the site in a manner consistent with the requirements of ASTM C94. Specifically, the concrete slump measurements at the point of discharge met the concrete design range of between 3 and 8 inches (with the addition of a high range water reducing agent). The concrete was sampled and tested at least once for every 100 cubic yards of delivered product. For the NRC observations of the SFP and ISFSI top pad, the actual concrete slump ranged from 4 to 7 inches. Grace Construction Products ADVA 190 was the high range water reducer specified in the concrete design used for the UMAX ISFSI project at SONGS.

During the NRC inspection, no concrete was placed that had exceeded either the 1½ hour time limit after the introduction of mixing water or with more than 300 turns on the truck's agitator drum. NRC inspectors observed that during concrete placement activities the trucks arrived on-site within 23-35 minutes after leaving the batch plant with about 180 turns on the drum. ADVA 190 high range water reducer was sometimes added to the concrete after the truck's arrival onsite. When ADVA 190 was added, the concrete was mixed at least 30 revolutions at mixing speed after its addition. No water additions were made once the delivery trucks arrived on-site for concrete placement.

One primary and two back-up concrete batch plants were contracted for the SONGS

UMAX ISFSI. The primary batch plant was located in San Clemente, CA. The back-up plants were in Irvine and Escondido, CA. NRC inspectors verified that the cement, aggregate, and water scales were calibrated and accurate to within the specifications of ASTM C94 requirements. NRC inspectors verified that water was batched by weight, not volume, to an accuracy of 1 percent of the required total water for the mix design of the SFP and ISFSI top pad. NRC reviewed a random selection of batch tickets for concrete delivered to the initial SFP and ISFSI top pad concrete placement events. Each set of batch tickets showed that individually weighted batching for the concrete mix used in the SFP and ISFSI top pad, weights for aggregates were within +/- 2 percent of the values specified in the concrete mix design, thereby meeting ASTM C94 requirements.

NRC inspectors verified that the ready mixed concrete provided for the UMAX ISFSI at SONGS met all of the applicable requirements of ASTM C94.

e. Concrete Placement Preparation

During each site visit to observe the concrete placement activities at SONGS, NRC inspectors verified that the concrete forms were securely shored, tight-fitting, and coated with release agent prior to concrete placement. NRC inspectors also verified that the reinforcement bars and subgrade were free from mud, oil, grease, debris, or any laitance that would inhibit bonding. Before the concrete pour, the subgrade and rebar was wetted, but standing water was not allowed in accordance with ACI 318 Section 5.7.1 (f). During concrete placement no paste or mortar leakage was observed coming from the bottom or between adjoining forms.

f. Concrete Placement

NRC inspectors observed workers placing concrete as nearly as practical to its final location. Operations were controlled to avoid segregation of the concrete due to re-handling or flowing. All concrete was observed as being placed in a plastic state which was easily worked by concrete operators and crew. Inspectors observed that the subcontractor did not place partially hardened or contaminated concrete during placement activities. Additionally, no re-tempered or remixed concrete was used during any concrete placement activities.

g. Concrete Sampling

Concrete sampling operations were observed by NRC inspectors to conform to ASTM C172 “Standard Practice for Sampling Freshly Mixed Concrete” requirements. Holtec Procedure HSP-186, “Aggregate and Ready Mixed Concrete Testing Requirements for ITS ‘B’ Applications,” Revision 23, step 5.3.3 required that concrete be tested as specified by ASTM C172. Procedure HSP-186 step 7.3 required that concrete for sampling should be acquired after 10 percent and before 90 percent of the mixer drum that had been discharged. The NRC inspectors verified during the observed portions of the SFP, SES, and ISFSI top pad placements that the concrete sampling practices employed on site adhered to the requirements specified in the standard and procedure.

Tests for slump, temperature, air entrainment, and unit weight were performed at the prescribed required intervals. The concrete sampling frequency was specified in

Procedure HSP-186 Step 7.15.1. Sampling was performed on the first truck each day to determine if the concrete arriving on-site met the required specifications. Additional sampling activities were performed on random trucks after each additional 100 cubic yards (yd^3) of concrete placement. This exceeded ACI 318 Section 5.6.2.1 minimum requirement for testing for each 150 yd^3 of concrete placement. Qualifications of the field testing technicians contracted by the licensee for concrete and grout sampling activities were reviewed by the NRC inspectors. All field testing technicians were certified as ACI Grade 1 or equivalent in accordance with ACI 318 Section 5.6.1.

Concrete test cylinders were molded in accordance with the ASTM C31 "Standard Practice for Making and Curing Concrete in the Field." Holtec Procedure HSP-186, Step 7.15.4 required the concrete cylinders to be prepared and cured in accordance with ASTM C31. NRC inspectors observed the testing personnel follow the requirements of ASTM C31 during sampling activities that took place during the NRC observations on the SFP, SES, and ISFSI top pad placements. Concrete test samples were molded and placed into a secure onsite structure where the temperature was monitored and maintained to between 60 and 80 degrees F. The samples were removed at the end of the day and taken to the testing laboratory for additional curing prior to break tests taking place at four, seven, 28, and 56 day intervals.

h. Concrete Curing

The SFP, SES layers, and ISFSI top pad did not meet the high-early-strength exemptions as defined in the ACI-318 Section 5.11.1 criteria. As such, the concrete was required to maintain in a moist condition for at least seven days after placement instead of just three days had the concrete met the high-early-strength criteria. After the concrete was placed for each section of the SFP, SES, and ISFSI top pad, Project Specification 3300 "Cast in Place Concrete," Step 3.4 E. required the licensee to keep the concrete temperature above 50 degrees F in a moist environment for seven days after placement. The NRC inspectors observed that the licensee was curing the concrete sections above the minimum temperature and were spraying water to keep the concrete moist for seven days as required by the code.

1.3 Conclusions

The subgrade and material that was beneath the completed ISFSI met the Holtec UMAX FSAR requirements for density and shear wave velocity. The 28 day concrete strength test reports confirmed that all sections of the UMAX ISFSI met the required concrete strength specified in the Holtec UMAX FSAR and design specifications. One violation of NRC regulations was identified associated with the licensee's failure to follow procedure steps to test the grout density that was placed below the CECs.

The rebar placement within both the SFP and the ISFSI top pad was constructed in accordance with Holtec UMAX FSAR and design specifications for the type of rebar used, spacing requirements, and minimum bend diameters. The rebar was placed within the forms to meet the minimum concrete cover requirements specified in the ACI standards to protect the rebar from corrosion. The yield and tensile strength test reports for the placed rebar were reviewed and found to meet the 60,000 pound per square inch (psi) minimum yield strength requirement specified in the Holtec UMAX FSAR.
The concrete mix used in the various sections of the Holtec UMAX met the design specification requirements in respect to slump, temperature, density, and water/cement

ratio. Concrete mix ingredients met the applicable ASTM and ACI standards for type of cement, admixtures, and water.

The ready-mix concrete batch plant that was used to construct the SONGS UMAX ISFSI had been inspected by the licensee and reviewed by the NRC to meet the requirements of ASTM C94, "Standard Specification for Ready-Mixed Concrete." The processes used for concrete mixing and delivery followed the ASTM standards with respect to maximum mixing time, maximum/minimum drum revolutions, addition of admixtures at the job site, and measurement of materials.

Concrete forms were adequately constructed and prepared in accordance with ACI requirements, including wetting of surfaces, removal of debris, control of mortar leakage, form deflection, removal of standing water, and application of release agents.

The concrete used in the SFP, SES sections, and ISFSI top pad at SONGS met the applicable ACI requirements for placement rate, exclusion of foreign material, no segregation of the material, and no use of re-tempered or remixed concrete.

The ACI and ASTM standards for concrete sampling were met with respect to sampling locations, methods, frequencies, number of samples, and methods for molding and curing strength test cylinders. The field technicians responsible for sampling and making the concrete test cylinders were certified as ACI Grade I Field Testing Technicians.

The concrete placed at SONGS for the UMAX ISFSI was maintained in a moist condition and cured for seven days as required by ACI standards.

2 Exit Meeting

The inspectors presented the inspection results to Mr. Lou Bosch, Plant Manager, and other members of your staff during a debrief meeting conducted on April 11, 2017. A final exit meeting was conducted telephonically on May 18, 2017 with licensing and engineering staff after the NRC inspectors received the 28-day concrete compressive strength break test results for the first section of the ISFSI top pad. Representatives of the licensee acknowledged the findings as presented.

SUPPLEMENTAL INSPECTION INFORMATION

PARTIAL LIST OF PERSONS CONTACTED

Licensee Personnel
J. Appel, Regulatory Affairs Engineer
J. Kay, Regulatory Affairs Manager
J. Lyles, Holtec Superintendent
J. Manso, ISFSI Sr. Project Manager
M. Moran, Engineering Manager
R. Munger, ISFSI Project Manager
J. Pugh, ISFSI Project Engineer
G. Rowe, Holtec QC Inspector
B. Vessels, Holtec Field Engineer

INSPECTION PROCEDURES USED

IP 60853 On-Site Fabrication of Components and Construction of an ISFSI

LIST OF ITEMS OPENED, CLOSED, AND DISCUSSED

Opened and Closed

07200041/2016002-01	NCV	Failure to test grout density in accordance with Holtec Procedure HSP-58

Discussed

None

Closed

None

LIST OF ACRONYMS

ACI	American Concrete Institute
ADAMS	Agencywide Documents Access and Management System
AHSM	advanced horizontal storage modules
ASTM	American Society for Testing and Materials
CAP	Corrective Action Program
CECs	Cavity Enclosure Containers
CFR	Code of Federal Regulations
CMTR	Certified Mill Test Results
CoC	Certificate of Compliance
DNMS	Division of Nuclear Material Safety
DSC	dry shielded canisters
F	Fahrenheit
FCR	Field condition report
ft/sec	feet per second
FSAR	Final Safety Analysis Report
GTCC	Greater-than-Class-C
ISFSI	Independent Spent Fuel Storage Installation
ITS	Important to Safety
MPC	Multi-Purpose Canister
MLLW	Mean Lower Low Water
NCV	Non-cited Violation
NRC	U.S. Nuclear Regulatory Commission
MSV	most severe earthquake
NN	Nuclear Notification
NUHOMS	Nuclear Horizontal Modular Storage
pcf	pounds per cubic foot
psi	pounds per square inch
QA	Quality Assurance
SCE	Southern California Edison
SES	Self-hardening Engineered Subgrade
SFP	Holtec HI-STORM UMAX ISFSI support foundation pad
SONGS	San Onofre Nuclear Generating Station
TS	Technical Specification
ISFSI top pad	Holtec HI-STORM UMAX ISFSI top pad
VVM	Vertical Ventilated Module

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☒ SUNSI Review By: LEB	ADAMS: ☒ Yes ☐ No	☐ Sensitive ☒ Non-Sensitive	☐ Non-Publicly Available ☒ Publicly Available	Keyword NRC-002

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