



**UNITED STATES  
NUCLEAR REGULATORY COMMISSION**  
REGION III  
2443 WARRENVILLE RD. SUITE 210  
LISLE, IL 60532-4352

May 6, 2016

Mr. John Sauger  
General Manager  
Zion Restoration Project  
ZionSolutions, LLC  
101 Shiloh Boulevard  
Zion, IL 60099

SUBJECT: NRC INSPECTION REPORT NO. 05000295/2016001(DNMS);  
05000304/2016001(DNMS)–ZION NUCLEAR POWER STATION

Dear Mr. Sauger:

On April 12, 2016, the U.S. Nuclear Regulatory Commission (NRC) completed an inspection at the permanently shut down Zion Nuclear Power Station (ZNPS). The NRC inspectors discussed the results of this inspection with Mr. Jerry Houff and other members of your staff. The inspectors documented the results of this inspection in the enclosed inspection report.

This inspection report documents a review of the following aspects of onsite activities: self-assessments, audits, and corrective actions; decommissioning performance and status review; occupational radiation safety exposure; final status surveys; and solid radioactive waste management and transportation of radioactive materials. The inspection consisted of an examination of activities at the site as they relate to safety and compliance with the Commission's rules and regulations. Areas examined during the inspection are identified in the enclosed report. Within these areas, the inspection consisted of a selective examination of procedures and representative records, observation of work activities, and interviews with personnel.

Based on the results of this inspection, no violations of NRC requirements were identified. In accordance with Title 10 of the *Code of Federal Regulations* (CFR) 2.390, "Public Inspections, Exemptions, Request for Withholdings," of the NRC's "Rules of Practice," a copy of

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Sincerely,

*/RA/*

Michael A. Kunowski, Chief  
Materials Control, ISFSI, and  
Decommissioning Branch  
Division of Nuclear Materials Safety

Docket Nos. 050-00295; 050-00304  
License Nos. DPR-39; DPR-48

Enclosure:  
IR 05000295/2016001(DNMS);  
05000304/2016001(DNMS)

cc w/encl: *ZionSolutions*, Service List

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U.S. NUCLEAR REGULATORY COMMISSION

REGION III

Docket Nos: 50-295; 50-304

License Nos: DPR-39; DPR-48

Report No: 05000295/2016001(DNMS)  
05000304/2016001(DNMS)

Licensee: Zion *Solutions*, LLC

Facility: Zion Nuclear Power Station

Location: Zion, Illinois

Dates: January 1, 2016, through April 12, 2016

Inspectors: Bill C. Lin, Health Physicist  
Peter J. Lee, Decommissioning (Reactor) Inspector,  
CHP, Ph.D

Approved by: Michael A. Kunowski, Chief  
Materials Control, ISFSI, and  
Decommissioning Branch  
Division of Nuclear Materials Safety

Enclosure

## **EXECUTIVE SUMMARY**

### **Zion Nuclear Power Station, Unit 1 and 2 NRC Inspection Report 05000295/2016001(DNMS); 05000304/2016001(DNMS)**

The Zion Nuclear Power Station (ZNPS) is a permanently shut-down and defueled power reactor facility that was maintained in a safe storage (SAFSTOR) condition from 1998 through 2010. Active decommissioning began in 2011, and continued throughout the inspection period. The spent fuel transfer campaign commenced in late 2013, and was successfully completed in January 2015. This routine safety inspection reviewed the licensee's ability to identify and correct problems. The inspectors also reviewed decommissioning activities related to the dewatering and cleaning of the spent fuel pool, Unit 2 steam generator waste characterization and transportation, final status surveys of the lube oil room of the turbine building, and generation of the embedded pipping survey procedures. The inspectors also discussed with the licensee about the Cobalt-60 (Co-60) hot particle event that occurred on March 16, 2016.

#### **Self-Assessment, Auditing, and Corrective Action**

- Issues were identified by the licensee at appropriate thresholds and entered into the corrective action program (CAP). Issues were screened and prioritized commensurate with safety significance. Licensee evaluations determined the significance of issues, and included appropriate remedial corrective actions. (Section 1.0)

#### **Decommissioning Performance and Status Review**

- The inspectors determined that the licensee and supplemental workforce conducted decommissioning activities in accordance with the regulations and license requirements. The inspectors conducted frequent plant tours to verify that the material condition of structures, systems, and conduct of safe decommissioning. (Section 2.0)

#### **Occupational Radiation Exposure**

- Radiation Work Permits (RWPs) and As Low As is Reasonably Achievable (ALARA) controls provided contamination controls and dose reduction measures appropriate for the work activities. Workers in general adhered to the radiological controls provided in the RWPs and ALARA plans and followed the radiation protection (RP) staff instruction.
- Decommissioning activities were executed in general alignment with planning documents and as provided in RWPs and ALARA reviews. Radiation surveys were performed.
- On March 16, 2016, a worker that was working in a non-contaminated area of the Fuel Handling Building had an intake of 35 nanocuries (nCi) of Co-60 (a hot particle). The licensee had been working on the dose assessment and root cause of the intake. The inspectors performed a dose assessment and determined that the dose at radiosensitive cells of the small intestine (SI) is well below the organ dose limit of 50 rem stated in 10 CFR 20. (Section 3.0)

## **Final Status Surveys**

- The inspectors reviewed the Source Term Survey (STS) results of the lube oil room in the turbine building. The licensee used In-Situ Object Counting System (ISOCS) to collect samples on the floor and wall. Each sample covered a surface area of 28 m<sup>2</sup>. The counting efficiency of ISOCS was appropriately determined for the sample analyses. Based on the review of the STS results, the inspectors determined that no radionuclides of concern (ROC) were positively identified.
- The inspectors reviewed the survey instrument calibration for the measurement of pipe inner surface using a gamma detector. The licensee proposed to take measurement in one foot intervals to cover all the inner surface of the pipe. To avoid the potential underestimation of the activity in each measurement interval, the licensee agreed to calibrate the detector with the source length of one foot. Since pipe inner surface measurement is based on gamma gross activity, the licensee has to determine the action level based on mixture of ROC and Basement Inventory Limit (BIL) or Derived Concentration Guideline Levels (DCGLs). The licensee agreed to determine the mixture of ROC based on the isotopic analyses of sediment collected from the interior of the pipe. (Section 4.0)

## **Solid Radioactive Waste Management and Transportation of Radioactive Materials**

- The inspectors determined that the Unit 2 steam generators were classified and characterized appropriately and shipped in accordance with all applicable Department of Transportation regulations. (Section 5.0)

## Report Details

### Summary of Plant Activities

During the inspection period, the licensee continued numerous decommissioning activities. Specifically, the dewatering and cleaning of the spent fuel pool, Unit 2 steam generator waste characterization and transportation, performance of the final status surveys for the lube oil room of the turbine building, and generation of the embedded pipping procedures. The licensee also had a Co-60 hot particle event during this inspection period.

#### 1.0 Self-Assessments, Audits, and Corrective Actions (Inspection Procedure (IP) 40801)

##### 1.1 Inspection Scope

The inspectors conducted document reviews and interviews with plant personnel to assess the licensee's performance as it related to the following areas:

- Administrative procedures prescribed actions for the identification, evaluation, and resolution of problems;
- Licensee procedures prescribed thresholds for the performance of self-assessments, audits, and surveillances;
- Licensee management reviewed self-assessments, audits, and corrective actions to remain knowledgeable of plant performance;
- Self-assessments were conducted with technically qualified personnel and sufficient independence from the licensee;
- Issues or problems were identified and corrected in accordance with the licensee's CAP through a sampling of select issues;
- Quality assurance personnel audited changes in the status of decommissioning and licensee organization; and
- Licensee management observed maintenance and surveillance activities, operations evolutions, and training.

The inspectors reviewed CAP documents to determine: if a sufficiently low threshold for problem identification existed; the quality of follow-up evaluations including extent-of-condition; and if the licensee assigned timely and appropriate prioritization for issue resolution commensurate with the significance of the issue. Issues that were repetitive and those with the potential for safety or regulatory consequence were evaluated further to assess apparent and/or common cause and significance. The inspectors also observed a sample of licensee corrective action review meetings to ascertain if the CAP procedures were implemented appropriately.

## 1.2 Observations and Findings

The inspectors determined that issues were identified by the licensee at an appropriate threshold within various functional areas of the site and entered into the CAP. Issues were effectively screened, prioritized, and evaluated commensurate with safety significance. The scope and depth of evaluations were adequate in that the evaluations reviewed addressed the significance of issues and assigned an appropriate course of remedial action.

The inspectors verified that self-assessments conducted during the inspection period were performed with technically qualified personnel, and when appropriate, utilized personnel independent of the licensee. Finally, the inspectors verified that quality assurance personnel continued to audit changes implemented at the plant.

No findings were identified.

## 1.3 Conclusions

Issues were identified by the licensee at appropriate thresholds and entered into the CAP. Issues were screened and prioritized commensurate with safety significance. Licensee evaluations determined the significance of issues and included appropriate remedial corrective actions.

## **2.0 Decommissioning Performance and Status Reviews (IP 71801)**

### 2.1 Inspection Scope

The inspectors conducted document reviews, observations, and interviews with plant personnel to assess the licensee's performance as it related to the following areas

- Status of decommissioning through the observation of licensee meetings that planned, reviewed, assessed, and scheduled the conduct of facility decommissioning;
- Whether licensee activities were in accordance with license conditions and docketed commitments, as well as, within the bounds of the docketed post-shutdown activity report;
- Operability and functionality of systems necessary for safe decommissioning were assessed through plant walkdowns of the following systems: radioactive effluent monitoring, radiation protection monitors and alarms, and equipment important to emergency preparedness;
- Verified pre-job briefs were conducted for facility operations, including maintenance, surveillance, operations, and decommissioning activities;
- Performed plant tours to assess field conditions and decommissioning activities; and
- Observed in-progress field work to verify activities were conducted in accordance with approved work instructions and workers were knowledgeable of tasks.



## 2.2 Observations and Findings

### Debris Cleanup and Dewatering of the Spent Fuel Pool

The inspectors determined through plant tours and observations that the licensee was performing the cleanup and dewatering of the spent fuel pool in accordance with the approved licensee procedures and regulatory requirements and had implemented applicable ALARA practices in most instances. The inspectors verified that the licensee had the applicable dosimetry, personal protection equipment, and that the RP staff had performed radiation surveys that characterized the radiation hazards involved during the cleaning and dewatering evolutions. The inspectors verified that all applicable briefings were performed as directed by the licensee's procedures.

No findings were identified.

## 2.3 Conclusions

The inspectors determined that the licensee and supplemental workforce conducted decommissioning activities in accordance with the regulations and license requirements. The inspectors conducted plant tours to verify that the material condition of structures, systems, and components supported the conduct of safe decommissioning.

## 3.0 **Occupational Radiation Exposure (IP 83750)**

### 3.1 Inspection Scope

The inspectors conducted document reviews, observations, and interviews with plant personnel to assess the licensee's performance as it related to the following areas:

- Planning and preparation for radiation work were adequate and if licensee management supported radiation protection planning;
- Personal dosimetry for external exposure met requirements;
- Management and administrative controls of external radiation exposure met requirements and were designed to keep exposures ALARA;
- Processes or engineering controls were used to the extent practicable to limit concentrations of airborne radioactive material;
- Survey and monitoring activities were performed as required;
- Control of radioactive materials and contamination met requirements; and
- Effective implementation of the ALARA program.

### 3.2 Observations and Findings

The licensee informed inspectors that on March 16, 2016, a worker that was working in a non-contaminated area of the Fuel Handling building had an intake of 35 nCi of Co-60 (hot particle). Once the licensee discovered that a worker had an intake, the licensee's RP staff checked the area air sampling results, interviewed applicable personnel that were working in the area, and performed the applicable bioassay and surveys. The licensee's initial findings were that there were no airborne contamination present, no other workers within the area had any intake of hot particles, and that the hot particle was present in the worker's SI. The hot particle stayed in the SI for about three weeks before it was excreted on April 7, 2016. The licensee is currently working on the root cause of the intake.

The inspectors performed a dose analysis based on the discussions with the licensee's RP staff. The wall of the SI is lined with a variable thickness of mucus. In addition, the radiosensitive cells are located at some depth into the mucosa. Because of that, the beta energy absorbed in the radiosensitive cells of the SI will be only a small fraction of that absorbed at the wall-contents interface. A Journal of Nuclear Medicine (1998, Volume 39, pp1989-1995) study used a mucus layer thickness of 200  $\mu\text{m}$ , villus height of 500  $\mu\text{m}$  and crypt depth of 150  $\mu\text{m}$  for the SI. Thus, the depth to the radiosensitive cells may be taken as approximately 850  $\mu\text{m}$  (85  $\text{mg}/\text{cm}^2$ ), which is about the maximum beta range of Co-60. All the beta energy will be absorbed in the mucosa layer, only gamma will deposit energy in the radiosensitive cells. To be conservative, the inspectors assumed the hot particle had stayed at the same location at the SI wall-contents interface prior to excretion. Based on Varskin, for 35 nCi of Co-60, the gamma dose rate averaged over 10  $\text{cm}^2$  at depth of 850  $\mu\text{m}$  is 0.64 mrem/hr. During 3-week exposure, the total dose received in the radiosensitive cells was about 338 mrem, which is well below the organ dose limit of 50 rem stated in 10 CRR Part 20.

### 3.3 Conclusions

The inspectors will review the licensee's root cause analysis once it is complete.

## 4.0 **Inspection of Final Status Surveys at Permanently Shutdown Reactors (IP 83801)**

### 4.1 Inspection Scope

The inspectors conducted document reviews, observations, and interviews with plant personnel to assess the licensee's performance as it related to the following areas:

- To verify that permanently shutdown power reactor sites have been decontaminated to acceptable residual radioactivity levels in accordance with the License Termination Plan (LTP) requirements for unrestricted or restricted use.
- To verify that the radiological measurements, surveys, and documentation of remedial action support surveys and final status surveys (FSSs) were conducted in accordance with the licensee's LTP and implementation procedure.
- To verify that the licensee's implementation or completion of remediation surveys have been adequately performed and the survey units have been prepared and were acceptable for the performance of FSSs.

- To verify the licensee's implementation of the FSS program was appropriate and to confirm the acceptability of the FSS results.

#### 4.2 Observations and Findings

##### a. Lube Oil Room

The inspectors reviewed the STS results of the lube oil room in the turbine building. The inspectors also discussed the sample analytical system with the licensee to determine the adequacy of the sampling results. The licensee used ISOCS to collect samples on the floor and wall. Each sample covered a surface area of 28 m<sup>2</sup>. The counting efficiency of ISOCS was appropriately determined for the sample analyses. Based on the review of the STS results, the inspector determined that no radionuclide of concern was positively identified.

##### b. Survey of Embedded Pipe

The inspectors reviewed the survey instrument calibration for the measurement of pipe inner surface using gamma detector. The licensee proposed to take measurements in one-foot intervals to cover all the inner surface of the pipe. The detection range of the gamma can reach several feet in the pipe. Therefore, if the calibration length is the same as measurement interval of one foot, the activity in the measurement interval will be overestimated if the contamination extends beyond the one-foot measurement interval. However, if the calibration length was less than the measurement interval, the activity in the measurement interval could be underestimated. To avoid the potential underestimation of the activity in each measurement interval, the licensee agreed to calibrate the detector with the source length of one foot. Since the pipe inner surface measurement was based on gamma gross activity, the licensee has to determine the action level based on mixture of ROC and BIL or DCGL. The licensee agreed to determine the mixture of ROC based on the isotopic analyses of sediment collected from the interior of the pipe.

The inspectors reviewed applicable STS survey results of the activities performed by the licensee's FSS group. Surveys were performed in accordance with applicable regulations and LTP, and no findings were identified.

#### 4.3 Conclusion

The licensee adequately implemented its STS of the lube oil room and embedded piping in accordance with all applicable regulations and the LTP.

### **5.0 Solid Radioactive Waste Management and Transportation of Radioactive Materials (IP 86750)**

#### 5.1 Inspection Scope

The inspectors conducted document reviews, performed interviews, and observed the licensee's classification and characterization of a planned waste shipment to determine:

- Whether detailed instructions and operating procedures were provided for transfer, packaging, and transport of low-level radioactive waste;

- Whether the material was properly classified, described, packaged, marked, and labeled for transportation; and
- Whether shipments were in compliance with NRC and Department of Transportation regulations.

## 5.2 Observations and Findings

The inspectors reviewed the Unit 2 steam generator radionuclides classification documentations, Microshield calculations, and survey results. Based on the review and discussion with the licensee's RP director, the inspectors determined that the licensee had accurately characterized the applicable radionuclides and generated the proper transportation documentations.

No findings were identified.

## 5.3 Conclusions

The licensee adequately implemented its solid radioactive waste and transportation programs in accordance with all applicable regulations.

## 6.0 **Exit Meeting**

The inspectors presented the results of the inspection to Mr. Jerry Houff and other members of the licensee's staff at a teleconference exit meeting on April 12, 2016. The licensee acknowledged the results presented and did not identify any of the information discussed as proprietary.

ATTACHMENT: SUPPLEMENTAL INFORMATION

## **SUPPLEMENTAL INFORMATION**

### **PARTIAL LIST OF PERSONS CONTACTED**

G. Van Noordennen, Vice President of Regulatory Affairs  
J. Ashley, Zion Licensing Engineer  
J. Houff, Licensing Manager  
J. Smith, Radiological Engineer  
T. Orawiec, Plant Manager  
B. Yetter, Characterization/License Termination Manager  
C. Keene, RP Director

### **INSPECTION PROCEDURES USED**

IP 40801 Self-Assessment, Auditing, and Corrective Action at Permanently Shutdown Reactors  
IP 71801 Decommissioning Performance and Status Reviews at Permanently Shutdown Plants  
IP 83750 Occupational Radiation Exposure  
IP 83801 Inspection of Final Status Surveys at Permanently Shutdown Reactors  
IP 86750 Solid Radioactive Waste Management and Transportation of Radioactive Materials

### **LIST OF ITEMS OPENED, CLOSED, AND DISCUSSED**

Opened  
None

Closed  
None

Discussed  
None

## PARTIAL LIST OF DOCUMENTS REVIEWED

The following is a partial list of documents reviewed during the inspection. Inclusion on this list does not imply that the NRC inspectors reviewed the documents in their entirety, but rather that selected sections of portions of the documents were evaluated as part of the overall inspection effort. Inclusion of a document on this list does not imply NRC acceptance of the document or any part of it, unless this is stated in the body of the inspection report.

- ALARA Review 2016-0-0037; Revision 1, February 8, 2016
- ALARA Work In-Progress Review 2016-0-0037; Revision 0, February 3, 2016
- ALARA Work In-Progress Review 2016-0-0037; Revision 1, March 17, 2016
- Radiological Work Permit 2016-0-0037
- TEDE ALARA Evaluation Screening Worksheet 2016-0-0037; Revision 1, February 8, 2016
- Brandenburg Work Execution Plan Demolition of Turbine and Service Building; Revision 0, October 5, 2015
- Technical Support Document 10-002; Technical Basis for Radiological Limits for Structure/Building Open Air Demolition; Revision 0
- Technical Support Document 15-006; Radionuclide Characterization of the Unit 2 Zion Steam Generators; Revision 1
- Zion Process Flow for Unconditional Release Survey (URS)
- ZS-LT-300-001-001; Final Radiation Package Development; Revision 2
- ZS-LT-300-001-002; Survey Unit Classification; Revision 2
- ZS-LT-300-001-003; Isolation and Control for Final Radiation Survey; Revision 2
- ZS-LT-300-001-004; Final Radiation Survey Data Assessment; Revision 2
- Zion ISOC 08 Survey Package
- FRS Survey for Turbine Building Basement for 560 elevation
- Surveys of Lube Oil Room of the Turbine Building
- Zion Liquid Release Permit Report; Permit No: 20160022
- Zion 2016 Lake Release xls
- CR-2016-00096; Demolition Work Caused Materials to Move; March 14, 2016
- CR-2016-000125; Water Leaking From U-1 Amertap Lines; March 24, 2016
- CR-2016-000113; Failure of the U-2 Discharge Canal Pump; March 29, 2016
- CR-2016-00016; Portal Monitor Intermittent Alarms; March 22, 2016
- CR-2016-000106; The Calibration Room Alarm System Failed to Function as Designed; March 20, 2016
- Zion Work Instructions; WBS 21555.21.10.24
- Zion Amertap Line Repair Package
- Zion Embedded Pipping Hard to Detect Surveys
- Zion Tendon Tunnel FSS result
- ZSRP Characterization Survey Package Attachment; August 27, 2012

## LIST OF ACRONYMS USED

ALARA	As Low As Is Reasonably Achievable
BIL	Basement Inventory Limit
CFR	Code of Federal Regulations
CAP	Corrective Action Program
Co-60	Cobalt-60
CR	Condition Report
DCGL	Derived Concentration Guideline Level
DNMS	Division of Nuclear Materials Safety
FSS	Final Status Survey
IP	Inspection Procedure
ISFSI	Independent Spent Fuel Storage Installation
ISOCS	In-Situ Object Counting
LTP	License Termination Plan
nCi	Nanocurie
NRC	U.S. Nuclear Regulatory Commission
ROC	Radionuclides of Concern
RP	Radiation Protection
RWP	Radiation Work Permit
SAFSTOR	Safe Storage
SI	Small Intestine
STS	Source Term Survey
ZNPS	Zion Nuclear Power Station