UNITED STATES
NUCLEAR REGULATORY COMMISSION
REGION II
245 PEACHTREE CENTER AVENUE NE, SUITE 1200
ATLANTA, GEORGIA 30303-1257

August 18, 2017

Mr. B. Joel Burch
Vice President and General Manager
BWXT Nuclear Operations Group, Inc.
P.O. Box 785
Lynchburg, VA 24505-0785

SUBJECT: BWXT NUCLEAR OPERATIONS GROUP – NUCLEAR REGULATORY COMMISSION INSPECTION REPORT NO. 70-27/2017-006 AND NOTICE OF VIOLATION

Dear Mr. Burch:

The Nuclear Regulatory Commission (NRC) conducted an announced inspection during the week of May 8, 2017, and in-office review thereafter, at the BWXT Nuclear Operations Group (NOG), Inc., facility in Lynchburg, VA. The purpose of the inspection was to perform Temporary Instruction (TI) 2600/16, Inspection of Activities Associated with NRC Generic Letter 2015-01, Treatment of Natural Phenomena Hazards in Fuel Cycle Facilities. The enclosed report presents the results of the inspection. At the conclusion of this inspection, the results were discussed with you and members of your staff at exit meetings on May 11, 2017, and July 27, 2017.

During the inspection, NRC staff examined activities conducted under your license as they related to public health and safety, and to confirm compliance with the Commission's rules and regulations, and with the conditions of your license. Areas examined during the inspection are identified in the enclosed report. Within these areas, the inspection consisted of selected examination of procedures and representative records, observations of activities, and interviews with personnel.

The inspection allowed the staff to independently verify compliance with regulatory requirements and applicable license conditions regarding the treatment of natural phenomena hazards (NPH) as described in your Integrated Safety Analysis (ISA).

Based on the results of the inspection, the NRC has determined that a Severity Level IV violation of NRC requirements occurred for failure to properly conduct and maintain an ISA that identifies potential accident sequences caused by natural phenomena. This violation was evaluated in accordance with the NRC Enforcement Policy. The current Enforcement Policy is included on the NRC's Web site at (http://www.nrc.gov/about nrc/regulatory/enforcement/enforce pol.html).

The violation is cited in the enclosed Notice of Violation (NOV) because the NRC identified the violation. The NOV and the circumstances surrounding it are described in detail in the subject inspection report.

The NRC has concluded that information regarding: (1) the reason for the violation; (2) the corrective actions that have been taken and the results achieved; and (3) the date when full compliance will be achieved is already adequately addressed. Therefore, you are not required to respond to this letter unless the description herein does not accurately reflect your corrective actions or your position. In that case, or if you choose to provide additional information, you should follow the instructions specified in the enclosed Notice.

If you contest the violation, 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 II and (2) the Director, Office of Enforcement, United States Nuclear Regulatory Commission, Washington, DC 20555-0001.

In accordance with Title 10 of the *Code of Federal Regulations* (10 CFR) 2.390 of NRC's "Rules of Practice and Procedure," a copy of this letter and enclosure 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), which is accessible from the NRC Website at http://www.nrc.gov/reading-rm/adams.html.

Should you have any questions regarding this inspection, please call me at (404) 997-4703.

Sincerely,

/RA/

Omar R. López-Santiago, Chief
Safety Branch
Division of Fuel Facility Inspection

Docket No. 70-27
License No. SNM-42

Enclosures:
1. Notice of Violation
2. NRC Inspection Report 70-27/2017-006
   w/Attachment: Supplemental Information

cc: (See page 3)

cc:
Joseph G. Henry
Chief Operating Officer
BWXT Nuclear Operations Group, Inc.
2016 Mount Athos Road
Lynchburg, VA 24505

Christopher T. Terry, Manager
Licensing and Safety Analysis
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P.O. Box 785
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SUBJECT: BWXT NUCLEAR OPERATIONS GROUP – NUCLEAR REGULATORY COMMISSION INSPECTION REPORT NO. 70-27/2017-006 AND NOTICE OF VIOLATION

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NOTICE OF VIOLATION

BWXT NOG, Inc.
Lynchburg, VA

Docket No. 70-27
License No. SNM-42

During a Nuclear Regulatory Commission (NRC) inspection conducted from May 8 -11, 2017, and subsequent in-office review ending July 27, 2017, a violation of NRC requirements was identified. In accordance with the NRC Enforcement Policy, the violation is listed below:

A. Title 10 of the *Code of Federal Regulations* (10 CFR) 70.62(c) requires, in part, that licensees shall conduct an ISA that is of appropriate detail for the complexity of the process that identifies the potential accident sequences caused by external events including natural phenomena.

   Contrary to the above, on and before May 11, 2017, the licensee failed to conduct an ISA that identified accident sequences involving the effect of natural phenomena, specifically seismic events, on racks on which special nuclear material is stored. Specifically, the licensee initially failed to consider potential accident sequences caused by components falling off racks that store special nuclear material; because the licensee failed to appropriately consider the seismic forces acting on components on the racks.

This is a Severity Level IV violation (Section 6.2.d.1).

The NRC has concluded that information regarding the reason for the violation, the corrective actions taken and planned to correct the violation and prevent recurrence, and the date when full compliance will be achieved, is already adequately addressed. However, you are required to submit a written statement or explanation pursuant to 10 CFR 2.201 if the description therein does not accurately reflect your corrective actions or your position. In that case, or if you choose to respond, clearly mark your response as a "Reply to a Notice of Violation," and send it to the U.S. Nuclear Regulatory Commission, ATTN: Document Control Desk, Washington, DC 20555-0001 with a copy to the Regional Administrator, Region II, and a copy to the NRC Resident Inspector, within 30 days of the date of the letter transmitting this Notice of Violation.

If you contest this enforcement action, you should also provide a copy of your response, with the basis for your denial, to the Director, Office of Enforcement, United States Nuclear Regulatory Commission, Washington, DC 20555-0001.

If you choose to respond, your response will be made available electronically for public inspection in the NRC Public Document Room or in 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. Therefore, to the extent possible, the response should not include any personal privacy, proprietary, classified, or safeguards information so that it can be made available to the Public without redaction.

In accordance with 10 CFR 19.11, you may be required to post this Notice within two working days.

Dated this 18th day of August, 2017

U. S. NUCLEAR REGULATORY COMMISSION

REGION II

Docket No:	70-27
License No:	SNM-42
Report No:	70-27/2017-006
Licensee:	BWX Technologies (BWXT)
Facility:	Nuclear Operations Group, Inc. (NOG)
Location:	Lynchburg, VA 24505
Dates:	May 8 through May 11, 2017; and in-office review ending July 27, 2017
Inspectors:	T. Sippel, Fuel Facility Inspector (Sections A.3, A.5, and A.6) J. Marcano, Structural Engineer (Sections A.1, A.2, A.4, and A.7)
Approved by:	O. López-Santiago, Chief Safety Branch Division of Fuel Facility Inspection

Enclosure 2

EXECUTIVE SUMMARY

BWXT Nuclear Operations Group, Inc.
NRC Inspection Report 70-27/2017-006
May 8 through May 11, 2017, and in-office review ending July 27, 2017

The inspection implemented Temporary Instruction (TI) 2600/16, Inspection of Activities Associated with Nuclear Regulatory Commission (NRC) Generic Letter (GL) 2015-01, Treatment of Natural Phenomena Hazards in Fuel Cycle Facilities. The purpose of the inspection was to independently verify that licensees are in compliance with regulatory requirements and applicable license conditions regarding the treatment of natural phenomena hazards (NPH) events as described in the Integrated Safety Analysis (ISA). The inspection was conducted by NRC regional inspectors and headquarters technical staff during normal shifts in areas of structural engineering, chemical safety, nuclear criticality safety, fire protection, and emergency preparedness. The inspectors performed a selective examination of license activities by observing safety-significant activities and equipment, facility tours, interviews and discussions with licensee personnel, and reviewing facility records.

Assessment of the Potential Accident Sequences, Consequences, and Prevention and/or Mitigation Strategies as a Result of Impacts to Facility Structures and Internal Components from NPH

With the exception of one documented violation (VIO), the licensee's ISA adequately considered credible events involving:

- Seismic-induced failure of principal buildings (Paragraph A.1);
- Seismic-induced failure of principal internal equipment (Paragraph A.2);
- Seismic-induced fire/explosion (Paragraph A.3);
- NPH-induced criticality (Paragraph A.5); and
- Flooding (Paragraph A.6)

One Severity Level IV violation of NRC requirements was identified for Failure to Appropriately Consider Accident Sequences Involving Seismic Events.

Special Topics

- Closure of Unresolved Item (URI) 2012-006-01, "Further Evaluate Licensee Compliance with 10 CFR 70.62(c) and the Performance Requirements of 10 CFR 70.61 Regarding Accident Sequences That are a Result of a Natural Phenomena Events." (Paragraph B.1).
- Opened URI 2017-006-02, Evaluate Management Measures Applied to Chemical Detector IROFS (Paragraph B.2).

Attachment:
Supplemental Information

REPORT DETAILS

Summary of Plant Status

The primary activity at the BWXT NOG facility is the production of nuclear fuel and components. BWXT NOG also operates the Lynchburg Technology Center (LTC) which is co-located at the Site and stores spent nuclear fuel from past testing, performs material analysis and testing of highly radioactive materials using its hot cells and chemical laboratory.

The inspection implemented Temporary Instruction (TI) 2600/16, Inspection of Activities Associated with Nuclear Regulatory Commission (NRC) Generic Letter (GL) 2015-01, Treatment of Natural Phenomena Hazards in Fuel Cycle Facilities. The purpose of the inspection was to independently verify that licensees are in compliance with regulatory requirements and applicable license conditions regarding the treatment of NPH events as described in the Integrated Safety Analysis (ISA). The inspection was conducted by NRC regional inspectors and headquarters technical staff during normal shifts in areas of permanent plant modifications, chemical safety, nuclear criticality safety, fire protection, and emergency preparedness. The inspectors performed a selective examination of license activities by observing safety-significant activities and equipment, facility tours, interviews and discussions with licensee personnel, and reviewing facility records.

A. Assessment of NPH Accident Sequences, Consequences, and Mitigation/Prevention Strategies

1. Seismic-Induced Failure of Principal Buildings

a. Inspection Scope

BWXT stated in its response to the Generic Letter 2015-01 that building structures were designed and constructed to comply with the Southern Building Code, Building Officials and Code Administrators International Code, and the International Building Code criteria for the year of construction. BWXT buildings are mainly constructed of steel with concentrically braced lateral force resisting systems. The buildings are composed of interconnected bays mostly 50 feet wide, 250 feet long, and 30 feet tall. A seismic analysis of the Main Bays and “A” Bays building structures was performed using American Society of Civil Engineers (ASCE) Standard 31-03: Seismic Evaluation of Existing Buildings and earthquake loads associated with a 2,500 year return period event correspond to an exceedance probability of two percent in 50 years.

The results of the analysis of Main Bays and “A” Bays building structures in accordance with ASCE 31-03 indicated that although some of the bracing is overloaded due to the current seismic loads, the structures meet the requirements for Life Safety Performance Level. The report recommended that the bracing in Bays 7, 7A, 12A, 13A, and 14A be reinforced to meet the more stringent criteria of Immediate Occupancy Performance Level as defined in ASCE 31-03 due to high value of the material in these bays and to improve the performance of the facility.

The inspectors conducted walk downs of the Main Bays and “A” Bays buildings; reviewed the design bases, calculations, and design drawings of a sample of buildings and interviewed the structural engineer. During the walk downs the inspectors verified, using a sample approach, that the as-built configuration of the buildings structures closely matched the finite element model used for the seismic evaluation. The

inspectors reviewed a sample of the specification drawings developed to add bracing in Bays 7, 7A, 12A, 13A, and 14A. The inspectors then observed a sample in the field to verify that the bracing was installed in the locations specified by the structural engineer.

b. Conclusion

No violations of NRC requirements were identified.

2. Seismic-Induced Failure of Principal Equipment

a. Inspection Scope

The licensee, in its response to GL 2015-01, did not conduct new quantitative seismic analysis of the internal equipment and tanks. BWXT provided an analysis to assess the consequences and likelihoods of a seismic induced event leading to criticality and to support the assumptions used in the assessments of seismic induced criticality events, the licensee provided analyses of the primary racks in which special nuclear material (SNM) is stored.

The inspectors selected a sample of major equipment and performed area walk downs to ensure that all potential hazards were considered in the seismic analysis and ISA. Specifically the inspectors performed walk downs of the process enclosures, process solution columns, process vessels, process storage racks and piping in the recovery areas. The inspectors reviewed the design bases, calculations, and design drawings of the storage racks relied upon to conclude that there are no potential consequences of a seismically induce nuclear criticality accident. NCS-TR-00002, Likelihood of a Criticality Accident Initiated by a Seismic Event at Mt. Athos, Revision (Rev.) 1, documents the licensee's safety basis for seismic events. Two overall 'bounding' rack types were considered, including vault type racks, and the Bay 7 type racks. This evaluation concluded that an earthquake causing items stored on the racks to go critical was incredible. The nuclear criticality calculation evaluated among other scenarios, the potential for containers and fuel assemblies falling from storage racks. Upon inspection and walk down of the supporting structural calculations documentation, the inspectors noted discrepancies between the analyzed conditions and the as-built conditions of the racks. The following summaries the two examples where discrepancies were found:

First Example: Bay 14 and other vault racks

Structural calculations used to calculate the safety margin against overturning under seismic loads, evaluated what was considered the most critical configuration of the rack. The structural calculation evaluated a rack with five storage locations per shelf and six shelves high for storage. The purpose of the rack calculation was to evaluate the factor of safety against overturning by imposing horizontal seismic loads to the components stored in the racks. The original calculation obtained seismic forces using an equation similar to equation 12.8-1 of ASCE 7-10 (below) for base shear (V).

$$V = C_s W \qquad (12.8\text{-}1)$$

Upon inspection and walk down of the racks the inspectors identified that the as-built condition of most of the racks is six storage locations per rack and five to six shelves high. During the walk downs the inspectors noted that there are different types of rack configurations such as, cantilever racks, braced at the top racks. In addition, it was not

clear, based on field inspections, if the maximum weight of material stored per location on the field could exceed the assumption used in the structural calculation to obtain the factor of safety against sliding. Furthermore, the inspectors noted that the structural capacity under load combinations including dead load, live load and seismic load of the columns, beams, supports and connections of the above mentioned racks was not assessed by the licensee. All of these factors may affect the performance under seismic loading of the racks and the conclusions used to evaluate the potential against overturning relied on for the criticality ISA evaluations.

The inspectors also noted that the factor of safety against overturning was obtained using the Equivalent Lateral Force (ELF) Procedure similar to that of Chapter 12 of ASCE 7. However, the calculation of forces from the ELF procedures is used for the design of structural members (lateral force resisting system, columns, beams, etc.). This procedures assumes that the seismic forces are distributed and resisted by a structural system and should not be used to quantify the forces on individual components that are sitting on the structure. To evaluate the loads imposed on individual components, the procedure for calculation of the seismic forces could be obtained using simplified static or dynamic methodologies derived from the typical physics equation of force (Force = mass * acceleration) with associated factors to account for the response of the system and the height of the component. An example of this methodology is used in Chapter 13 of ASCE 7 for the evaluation of non-structural components. Therefore, the initial calculations for Bay 14 racks failed to adequately address the potential for overturning and toppling of components. This calculation was used in the nuclear criticality calculation to demonstrate that the performance requirements of Title 10 of the *Code of Federal Regulations* (10 CFR) 70.61 were met.

To address the deficiencies identified by the NRC during the inspection, the licensee performed new calculations. Which were documented in Project N0. 260-005-277, “BWXT-Areas 2,3,4,5, and 6”, Rev. 1.0, dated June 1, 2017. The purpose of the calculation was to evaluate the design of vault racks, sliding and overtopping of canister from racks. The calculation referenced MH16.1-2012, “Specification for the Design, Testing and Utilization of Industrial Steel Storage Racks”; International Building Code 2012; ASCE 7-10, “Minimum Design Loads for Buildings and Other Structures”; and AISC Steel Construction Manual 2008. The inspectors performed in-office reviews of the calculations and did not identified issues with the methodology and determination of load forces on members. The section of container tipping uses equation 13.3-1 of ASCE 7-10 (equation below) to calculate the forces on the containers from seismic loads to compare against the resisting force due to the weight of the container to prevent the container from tipping.

$$F_p = \frac{0.4 a_p S_{DS} W_p}{\left(\frac{R_p}{I_p}\right)}\left(1+2\frac{z}{h}\right) \qquad (13.3\text{-}1)$$

However, some of the assumptions used to obtain the seismic force (F_p) were not adequately justified in the calculation leading to potential non-conservative results. Specifically the following two assumptions were not appropriately justified: 1) The use of a component response modification (R_p) factor of 3.5 has not been adequately justified. Because the components being analyzed are not attached to the structure, the components have a low deformability, and an R_p greater than 1.5 needs to be adequately justified. 2) The use of a reduction factor of .7 on the earthquake force obtained using equation 13.3-1 from ASCE 7-10. The calculation indicates that a .7

"Service Factor" was applied. Service Factors are used when loads are compared to member or component allowable values that are less than the full strength of the member or component. They are applied to the load combinations but also are applied to the capacities. In the calculation the forces obtained from equation 13.3-1 the F_p should not be factored since the resisting moment (M_R) is not a "load" that has been reduced with a factor.

All of these discrepancies, have the potential to impact the structural seismic assessment of the overturning coefficient used in the criticality calculation. However, based on the inspectors independent calculations with the above mentioned factors changed to an R_p of 1.5 and no service factor applied, the top 2 shelves could have containers overturning. The factor of safety against overturning is above 1 but less than 1.5 at the top shelve. With this information, and the previous BWXT criticality analyses (NCS-TR-00002, Rev. 1) that considered the potential for a criticality event due to sliding and overturning on the top two shelves, the staff concludes that it can be shown that this event is highly unlikely.

Second Example: Bay 7 racks

Structural calculations used to evaluate the performance of the racks under seismic loads and the safety margin against sliding had discrepancies between the analyzed condition and the as-built condition. More specifically, upon walk downs of the racks the inspectors noted that the anchors for a vast majority of the racks were different than the anchors modeled in the analysis. The original calculation assumed that the racks where anchored at the front and the rear of the base of the rack and the as-built condition had only anchors at the front of the base of the rack. Anchorage of storage racks is an important attribute that could impact the overturning of the rack under seismic loading. In addition, the number of bolts connecting the storage arms to the rack column was different than modeled in the original calculation. The original calculation assumed 4 bolts per connection whereas the vast majority of the connections had only two bolts. Using the wrong number of bolts in the connection could lead to non-conservatively overestimating the ability of the rack to hold its components under imposed loads.

Similar to the Bay 14 and other vault racks, the factor of safety against sliding was obtained using the Equivalent Lateral Force Procedure on Chapter 12 of ASCE 7. However, the calculation of forces from the ELF procedures is used for the design of structural members (lateral force resisting system, columns, beams, etc.). This procedures assumes that the seismic forces are distributed and resisted by a structural system and should not be used to quantify the forces on individual components that are sitting on the structure.

To address the deficiencies identified by the NRC during the inspection, the licensee performed a new calculation (Project No. 260-005-242, "Design of storage Racks," Rev. 2, dated May 30, 2017). The purpose of the calculation was to evaluate the design of Bay 7 racks, and the factor of safety against sliding of fuel bearing components from the racks. The calculation referenced MH16.1-2012, "Specification for the Design, Testing and Utilization of Industrial Steel Storage Racks"; International Building Code 2012; ASCE 7-10, "Minimum Design Loads for Buildings and Other Structures"; and AISC Steel Construction Manual 2008. The inspectors performed in-office reviews of the calculations and did not identify issues with the methodology and determination of load forces on the rack members including the results with anchor bolts in the front and two bolts per connection.

However, similar to the example for the Bay 14 and other vault racks, the section of product sliding (Section 5.5) uses equation 13.3-1 of ASCE 7-05 to calculate the forces on the product from seismic loads to compare them against the sliding resistance from friction. The assumptions used to obtain the seismic force F_p were not adequately justified in the calculation leading to potential non-conservative results. Specifically the following two assumptions were not appropriately justified: 1) The use of an R_p component response modification factor of 3.5 has not been adequately justified. Since the product analyzed is not attached to the structure, the components have a low deformability and an R_p of greater than 1.5 needs to be adequately justified. 2) The use of a reduction factor of .7 on the earthquake force obtained using equation 13.3-1 from ASCE 7-10. The calculation indicates that a .7 "Service Factor" was applied. Service Factors are used when loads are compared to member or component allowable values that are less than the full strength of the member or component. They are applied to the load combinations but also are applied to the capacities. In the calculation the forces obtained from equation 13.3-1 the F_p should not be factored since the M_R is not a "load" that has been reduced with a factor.

In addition, a modal analysis[1] was performed to validate the results of the hand calculations and forces obtained from equation 13.3-1 (ELF). The inspectors performed an in-office reviewed of the calculation and noted that the calculation has limited information to described how the modal analysis was performed. However, the inspectors identified that the results of the modal analysis were incorrectly used to calculate a "new" S_{ds} by obtaining base shear (joint loads or reactions) at the base of the racks and using equation 12.8-1 of ASCE 7-10. S_{ds} is used in the design equations of ASCE 7-10 Chapter 12.8 to obtain the seismic base shear and represents the 5% damped, spectral response acceleration parameter at short periods. S_{ds} and base shear are correlated by the following two equations below.

$$V = C_s W \qquad (12.8\text{-}1)$$

$$C_s = \frac{S_{DS}}{\left(\frac{R}{I_e}\right)} \qquad (12.8\text{-}2)$$

Using equations 12.8-2 and 12.8-1 the licensee obtained a lower S_{ds} value that was used to obtain a lower seismic force using equation 13.3-1 of ASCE 7-10 rather than calculating the forces using equation 13.3-4 of ASCE 7-10 which is the equation applicable to modal analysis. Calculating a lower seismic force by using a lower S_{ds} is not the intent of the code methodology for the use of modal analyses. Earthquake input or demands cannot be "back-calculated" by using modal analysis to lower the seismic force. Instead, a properly performed modal analysis provides a better analysis of a structural behavior under an assigned demand or earthquake.

All of the above mentioned discrepancies have the potential to impact the structural seismic assessment of the sliding of product from the Bay 7 racks. Therefore, the inspectors were not able to conclude that the licensee has adequately addressed the potential for product sliding from the Bay 7 racks. As a result of these inspector-

[1] ASCE 7-10 provides 3 analytical procedures to calculate seismic forces in structures. Equivalent Lateral Force (Chapter 12.8), Modal response spectrum analysis (Chapter 12.9) and Response history analysis.

identified issues the licensee re-evaluated the potential for criticality assuming fuel bearing components slide of the racks in NCS-TR-0002, Rev. 3. The inspectors' review of this analysis is documented in Section 5 of this inspection report.

b. Conclusion

No violations of NRC requirements were identified. However, the issues identified in this section are further evaluated in Section 5 of this inspection report.

3. Seismic-Induced Fire/Explosion

a. Inspection Scope

Based on the response to the GL, the licensee did not identify any new fire-related accident sequences because seismically induced fires and explosions were bounded by existing accident sequences. As part of the existing ISA, the licensee evaluated the consequences from generic fires and explosions, including some cases where seismically induced fires were explicitly analyzed. The inspectors conducted walkdowns of areas containing fire hazards, including Uranium Recovery (UR), natural gas lines, and flammable gas storage areas, and interviewed licensee engineers and management to verify that the existing fire assessments remain valid during a credible NPH event.

The inspectors conducted walk downs of flammable gases (e.g., hydrogen, natural gas) and water shutoff valves with licensee engineers and noted that there are isolation points located both inside and outside of the various process buildings. Isolation points consisted of manual valves, and pushbutton kill switches. The inspectors concluded that there are multiple methods to shutoff flammable gases and water supplies if needed following an NPH event.

The inspectors reviewed applicable emergency preparedness procedures to determine if the licensee identified adequate response actions to isolate flammable gases and hazardous energy sources in the event of an earthquake. The inspectors noted that the procedures do contain generic steps to walkdown the facility and EPR-02-07-01, "Safe Shutdown of Facility Operations Checklist," contains a list of hazards by area for licensee staff to verify safe shutdown or put in a safe configuration. This checklist includes closing flammable gas shutoff isolation valves.

The inspectors performed walkdowns of main water facility lines used for fire mitigation. Specifically, the inspectors walked down the main shut off valves for the fire water lines and noted that the licensee has the equipment to bypass the fire water tanks in the event of an emergency or rupture of the tanks. To bypass the fire water tanks, the licensee has 5 inch hoses to connect the main water supply line directly to the plant fire water distribution line. In addition, the inspectors discussed the emergency use of river water with licensee emergency response and fire staff. The inspectors concluded that there are multiple methods to provide water for fire mitigation if needed following an NPH event.

b. Conclusion

No violations of NRC requirements were identified.

5. NPH-Induced Criticality

a. Inspection Scope

The inspectors evaluated the adequacy of the licensee's nuclear criticality safety (NCS) program and analyses to assure the safety of fissile material operations and compliance with respect to NPH events. The inspectors reviewed select NCS documents (listed in Section 4.0 of the Attachment). The inspectors verified the technical basis for NCS controls and assumptions, evaluated potential NPH-related criticality accident sequences, and verified that the licensee performed evaluations to assure sub-criticality of processes under normal and credible abnormal conditions, with a focus on potential abnormal conditions that could be caused by NPH.

The inspectors reviewed NCS evaluations and analyses to determine whether the licensee evaluated normal and credible abnormal conditions for NCS, reviewed the associated criticality accident sequences, reviewed the purpose and technical basis for any controls implemented to prevent these criticality accident sequences (e.g., the floor), verified that controls identified to prevent these criticality accident sequences would be effective and independent, verified that these controls were installed and/or implemented as intended, and evaluated whether the likelihood of these accident sequences was limited to regulatory limits.

The licensee did not identify any new credible criticality accident sequences that were not bounded by existing sequences. Likewise, no new items relied on for safety (IROFS) were established to limit the likelihood of a NPH-induced criticality accident. The inspectors determined that the licensee adequately identified credible NPH-related accident sequences and limited their likelihood as documented in NCS-TR-00002, Likelihood of a Criticality Accident Initiated by a Seismic Event at Mt. Athos; with the exceptions listed below.

The inspectors performed plant walk downs in UR, the Specialty Fuel Facility (SFF), a number of vaults, and other areas where SNM is handled or stored. The inspectors interviewed Operations' staff and NCS engineers both before and during walk downs. The inspectors visually verified that controls identified in the applicable NCS evaluations were installed and/or implemented as designed. The inspectors verified that management measures designed to maintain IROFS were being performed within their assigned frequency and in accordance with procedures.

The inspectors verified that the licensee evaluated the ability of the criticality accident alarm system to perform its safety function, trigging an evacuation, during and after a seismic event.

The inspectors reviewed the site Emergency Plan to ensure that mitigative actions with regard to an inadvertent criticality due to flooding and other natural phenomena were evaluated.

b. Conclusion

The inspectors identified the following Severity Level (SL) IV Violation.

Failure to Appropriately Consider Accident Sequences Involving Seismic Events

Introduction: The inspectors identified a cited SL IV Violation of 10 CFR 70.62(c) with two examples of failure to appropriately consider accident sequences involving the effect of natural phenomena, specifically seismic events, on racks on which special nuclear material is stored. Specifically, the licensee initially failed to consider potential accident sequences caused by components falling off racks that store special nuclear material; because the licensee failed to appropriately consider the seismic forces acting on components on the racks.

Description: Historically the licensee has not specifically considered NPH sequences in their evaluations. As a result of GL 2015-01, the licensee issued NCS-TR-00002, Likelihood of a Criticality Accident Initiated by a Seismic Event at Mt. Athos, Rev. 1, to document their safety basis for seismic events. Two overall 'bounding' rack types were considered, a vault type rack, and the Bay 7 type racks. This evaluation concluded that an earthquake causing items stored on the racks to go critical was incredible. For the Bay 7 racks they used the seismic/structural analysis to conclude that items would not slide off the racks and that the racks would not topple over. Thus, the licensee concluded that seismically induced criticality was incredible in the Bay 7 type racks. For the vault style racks the licensee's seismic calculations showed that items may slide off the top few shelves. Therefore, in NCS-TR-00002, Rev. 1, the licensee evaluated the conditional probabilities of enough items sliding off and falling into a critical configuration. Based on these analyses the licensee determined that the total likelihood of an earthquake causing bottles to slide off and fall into a critical configuration was less than 10^{-5} per year.

As discussed in Section 2.a above, the inspectors walked down the various racks and reviewed the seismic calculations and noted that there was enough variation in the design of the racks (e.g., different bolt configurations, more storage locations) that the 'bounding' racks in the analysis did not bound all the racks. The inspectors also noted that the licensee miscalculated the force an earthquake would apply to items on racks because they used the wrong equation. The licensee conducted walk downs of the racks, performed a new seismic analysis, and issued NCS-TR-00002 Rev. 2 to address these issues. The licensee correctly bounded the various rack designs in this revision. However, in their seismic calculations to obtain the factor of safety against sliding and overturning, the inspectors identified deficiencies with the assumptions used to obtain the seismic forces which resulted in the wrong force being applied despite using the correct equation. Further details describing this deficiencies is provided above in Section 2.a of this inspection report. For the vault type racks the licensee changed their methodology to perform a 'tip over' calculation instead of a sliding calculation because during their walk downs they noted the presence of a lip that would prevent sliding. Based on the correctly calculated force the inspectors noted that items could fall from the top few shelves of the vault racks. Because the licensee already analyzed the conditional probability of criticality if items fall from these shelves during an earthquake (in NCS-TR-00002 Rev. 1), sufficient information existed between the two revisions to conclude that the total likelihood of an earthquake causing bottles to slide off and fall into a critical configuration was less than 10^{-5} per year.

For the Bay 7 type racks the licensee calculated that no items would slide off, however, the inspectors determined that when the correct force is used, all or most of the items could fall off. In order to address this issue the licensee issued NCS-TR-00002 Rev. 3 to evaluate what happens when items fall off. Firstly, they determined that even if all items fell from every shelf except the bottom most shelf, there would not be a criticality provided moderator is limited. The inspectors noted that this depends on the current design of the Bay 7 area (e.g., open floor, limited water pipes). The limited moderator considered by the licensee would account for things like water sprays and puddles. In NCS-TR-00002 Rev. 3, the licensee did not consider any probabilities associated with this amount of water, but conservatively assumed it would always result from an earthquake. The licensee also modeled results from all items falling from all shelves and determined that some configurations could go critical. The licensee then calculated the conditional probability that items would fall into these configurations, and concluded that the overall probability resulting from items falling during an earthquake was less than 10^{-5} per year.

Analysis: 10 CFR 70.62(c) requires, in part, that licenses shall conduct an ISA that is of appropriate detail for the complexity of the process that identifies the potential accident sequences caused by external events including natural phenomena.

The inspectors determined that the licensee did not initially conduct an ISA of appropriate detail for the racks that identified potential accident sequences caused by natural phenomena (specifically, seismic events).

Although seismic/structural design issues are not clearly addressed in Inspection Manual Chapter (IMC) 0616 Appendix B, a similar example for NCS, minor/more-than-minor Example 2(d), considers a noncompliance more than minor if, “The modeled conditions were not conservative…” Which would make this noncompliance more than minor. Additionally, IMC 0613 Appendix E Screening Question 1, does address structural issues; it asks in part “Does the performance deficiency represent a substantive non-conservative error in a specification… calculation, or other design document that defines the technical requirements for a structure, system, or component?” and contains guidance that “the inspector should consider (within reason) whether the issue will require the licensee to perform substantive efforts to determine the suitability of the SSC. ... Examples of substantive efforts may include, but are not limited to, a detailed engineering analysis … to establish the suitability of an item or activity.” Which also makes this noncompliance more than minor.

However, the inspectors concluded that there was no actual safety significance because no criticality occurred. Based on the new analysis in NCS-TR-00002 (Rev. 1 and 3), the inspectors determined that the performance requirements of 10 CFR 70.61 were still met due to the probability of a sufficient number of items falling into a critical configuration and the limited amount of moderator available.

In accordance with the NRC Enforcement Policy, violations that are less serious, but are of more than minor concern, and result in no or relatively inappreciable potential safety or security consequences are characterized as SL IV violations.

Enforcement: 10 CFR 70.62(c) requires, in part, that licenses shall conduct an ISA that is of appropriate detail for the complexity of the process that identifies the potential accident sequences caused by external events including natural phenomena.

Contrary to the above, on and before May 11, 2017, the licensee failed to conduct an ISA that identified accident sequences involving the effect of natural phenomena, specifically seismic events, on racks on which special nuclear material is stored. Specifically, the licensee initially failed to consider potential accident sequences caused by components falling off racks that store special nuclear material; because the licensee failed to appropriately consider the seismic forces acting on components on the racks. In NCS-TR-0002, Rev. 3, the licensee documented a detailed NCS analysis of the configurations necessary for a criticality and their probability of occurring given an earthquake. The analysis demonstrated that the potential for an earthquake to cause items to fall off shelves into a critical configuration is less than 10^{-5} per year. In COM-65131, the licensee committed to update the ISA to include the pertinent information pertaining to the analysis of the racks.

In accordance with the NRC Enforcement Policy, violations that are less serious, but are of more than minor concern, and result in no or relatively inappreciable potential safety or security consequences are characterized as SL IV violations. The failure to appropriately consider accident sequences involving seismic events is a SL IV violation of NRC requirements and will be tracked as VIO 70-27/2017-006-01, "Failure to Appropriately Consider Accident Sequences Involving Seismic Events."

6. Flooding, Local Intense Precipitation, and Snow Loading

a. Inspection Scope

In their response to the Generic Letter (dated September 18, 2015), the licensee's analysis concluded that flood levels would only impact the Rail Yard Storage, Container Storage Facility, and Waste Treatment Facility (WTF). As the active uranium storage and processing portions of the site are located well above the Probable Maximum Flood even when dam breaks and wave action are considered. The criticality safety evaluations for the Rail Yard Storage and Container Storage already include total submersion in water, so the effects of flooding are already considered. The WTF would also be flooded during the Probable Maximum Flood, and the licensee has procedures in place to shutdown operations, and secure equipment and material, in preparation for flooding. The inspectors reviewed the emergency response procedure that covers the response to flooding to determine if the licensee had established adequate guidance to respond to a flood. The procedure assigns responsibilities to use the national weather service to anticipate flooding, relocate equipment and supplies, and activate the emergency operations center. In addition, the WTF is operated under mass control limits so flooding would not be expected to result in a criticality even if no actions were taken in response to the flood.

b. Conclusion

No violations of NRC requirements were identified.

B. Special Topics

1. Follow-up on Previously Identified Issues

a. (Closed) Unresolved Item (URI) 2012-006-01, Further Evaluate Licensee Compliance with 10 CFR 70.62(c) and the Performance Requirements of 10 CFR 70.61 Regarding Accident Sequences That are a Result of a Natural Phenomena Events

Following the earthquake at the Fukushima Dai-ichi nuclear power station in March 2011, the NRC conducted TI 2600/015, Evaluation of Licensee Strategies for the Prevention and/or Mitigation of Emergencies at Fuel Facilities, in December 2011, to confirm compliance with applicable regulatory requirements and license conditions; and to evaluate licensee's readiness to address NPH events and other licensing bases events related to NPH. The NRC was unable to verify that BWXT was in compliance with their licensing basis and regulatory requirements with respect to NPH. Specifically, the inspectors could not confirm that all credible external events (accident sequences) involving process deviations or other events internal to the facility (e.g., consequential explosions, spills, and fires resulting from NPH event) were properly considered in the ISA. As a result the inspectors opened this URI.

Following the completion of TI 2600/015, the NRC concluded that this was a generic issue and subsequently issued NRC GL 2015-01, "Treatment of Natural Phenomena Hazards in Fuel Cycle Facilities," in June 2015. The GL requested licensees to provide additional information to support a determination with regard to proper evaluation of NPH impacts at fuel cycle facilities. The licensee submitted a response to the GL dated September 18, 2015. Additional correspondence on this topic are listed in Section 4 of the Attachment.

During the inspection, the NRC reviewed this open URI to verify that the licensee had complied with regulatory requirements and applicable license conditions regarding the treatment of NPH events in the ISA. The results of the inspection are documented in Section A of this inspection report. Based on the inspections performed, the NRC has concluded that BWXT is in compliance with regards to the regulatory requirements specified in 10 CFR Part 70.61, Subpart H, with respect to the assessment of NPH hazards in the ISA. With the exception of VIO 70-27/2017-006-01, which is discussed above. This URI is considered closed.

b. (Opened) URI 2017-006-02, Evaluate Management Measures Applied to Chemical Detector IROFS

Introduction: The inspectors identified an URI associated with the adequacy of management measures applied to chemical detector IROFS in the SFF. These detectors are relied on to detect unsafe chemical conditions and initiate actions to mitigate or prevent the hazard (e.g., detect a high level of explosive gas and close the supply valve).

Description: During this inspection, questions were raised about the testing of the IROFS fail safe features. Specifically, the status of chemical detector IROFS upon loss of power. As the testing performed at the time of the inspection only addressed the detectors functionality upon exposure to a test gas, this leaves other portions of the IROFS that are necessary for the IROFS to perform its function not clearly addressed. The licensee stated that the supply valves are normally closed, and will close upon loss

of power/signal holding them open. However, this feature is not clearly specified or tested as part of the chemical detector IROFS. This issue will be tracked as URI 70-27/2017-006-02.

C. Exit Meeting

The inspection scope and results were summarized in exit meetings on May 11, 2017, and July 27, 2017, to B. J. Burch and staff. The inspectors received no dissenting comments from the licensee. Proprietary and security-related information were discussed but not included in the report.

SUPPLEMENTAL INFORMATION

1. KEY POINTS OF CONTACT

Name	Title
D. Ashworth	Chemical Engineer
B. J. Burch	Vice President and General Manager
J. Calvert	Environmental, Safety, Health & Security Program Manager
K. Conway	Unit Manager, Radiation Protection
M. Edstrom	Fire Protection Engineer
D. Faidley	Unit Manager, Nuclear Criticality Safety
C. Terry	Unit Manager, Licensing and Safety Analysis
L. Wetzel	Senior Advisory Engineer

Other licensee employees contacted included engineers, technicians, production staff, and office personnel.

2. LIST OF ITEMS OPENED, CLOSED, AND DISCUSSED

Closed

70-27/2012-006-01	URI	Further Evaluate Licensee Compliance with 10 CFR 70.62(c) and the Performance Requirements of 10 CFR 70.61 Regarding Accident Sequences That are a Result of a Natural Phenomena Events

Opened

70-27/2017-006-01	VIO	Failure to Appropriately Consider Accident Sequences Involving Seismic Events
70-27/2017-006-02	URI	Evaluate Management Measures Applied to Chemical Detector IROFS

3. INSPECTION PROCEDURES USED

TI 2600/16, Inspection of Activities Associated with NRC Generic Letter 2015-01
IP 88015, Nuclear Criticality Safety
IP 88020, Operational Safety
IP 88050, Emergency Preparedness
IP 88055, Fire Protection
IP 88070, Permanent Plant Modifications

4. DOCUMENTS REVIEWED

Records:
B.L Morcom, “Forces on Bay 7 High Rise Storage”, dated September 24, 2017
Design of Storage Racks Bay 7, Rev. 1, dated February 4, 2017
Design of Storage Racks Bay 7, Rev. 2, dated May 30, 2017

Emergency Plan, Various Sections
Evaluation of Storage Racks Areas 2, 3, 4, 5, & 6, Rev. 1, dated June 1, 2017
HS-2012-066, Nitric Acid Releases from Combustible Liquid Pool Fires in Recovery
NCS-2017-015, NCS measurements to verify the flatness of the floor in Bays 13A, 14A, and 15A, dated January 19, 2017
NCS-2017-088, Determination of the Coefficient of FwetFriction for Zirconium on Buna Rubber and Polyethylene, dated May 25, 2017
NCS-TR-00002, Likelihood of a Criticality Accident Initiated by a Seismic Event at Mt. Athos, Rev. 1, dated August 23, 2016
NCS-TR-00002, Likelihood of a Criticality Accident Initiated by a Seismic Event at Mt. Athos, Rev. 2
NCS-TR-00002, Likelihood of a Criticality Accident Initiated by a Seismic Event at Mt. Athos, Rev. 3, dated June 27, 2017
RPTWR 04-014, Evaluation of a Glovebox Fire to Environmental and Occupational 10 CFR 70.61 Limits
RPTWR 04-019, Analysis of the 10 CFR 70.61 Related Effects of a Large Area Fire in The Recovery Areas
RPTWR 05-016, Evaluation of Glovebox Fires and Deflagration to Environmental and Occupational 10 CFR 70.61 Limits (SAR 15.33 and SAR Introduction)
RPTWR 05-017, Risk Assessment of Severity of Radiological Consequences for Fires and Spills Involving Radioactive Materials Under License SNM-42, Rev. 2
RPTWR-12-020, James River and Flooding at the B&W Mount Athos Facility, Rev. 0

Procedures:
EPR-01-01, Emergency Plant Evacuation
EPR-01-05, Emergency Response to James River Flooding, Rev. 4
EPR-02-02, Industrial Safety Assessment for Hazmat Response, Rev. 5
EPR-02-07-01, Safe Shutdown of Facility Operations Checklist, Rev. 8
EPR-02-07-02, Natural Phenomena Event Facility Status Checklist, Rev. 3
EPR-03-07, Response to Severe Weather, Rev. 20
EPR-03-09, Severe Weather Evacuation Contingency, Rev. 17
EPR-03-10, Personal Protective Equipment for Haz Mat Response, Rev. 4
EPR-03-11, Haz Mat Incident Control & Mitigation, Rev. 7
OP-0021001, Rev. 84
OP-0061167, Spill and Leak Handling Emergency Procedure, Rev. 32

Condition Reports Written as a Result of this Inspection:
CA201700660, COM-65131

Other Documents:
Form M11-P-029, Rev. 33, various dates

NRC/BWXT Generic Letter Communications:
NRC Generic Letter 2015-01, Treatment of Natural Phenomena Hazards in Fuel Cycle Facilities, dated June 22, 2015, ADAMS Accession Number ML14328A029
Reply to General Letter 2015-01: Treatment of Natural Phenomena Hazards in Fuel Cycle Facilities dated June 22, 2015, dated September 18, 2015, ADAMS Accession Number ML15272A314
Requested Information Regarding Natural Phenomena Hazards (NPH), dated February 25, 2016, ADAMS Accession Number ML16068A155
Reply to Request for Supplemental Information Concerning Response to Generic Letter 2015-01, dated July 14, 2016, ADAMS Accession Number ML16202A043