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

June 18, 2015

EA-15-021
EN-50776

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

SUBJECT: BABCOCK AND WILCOX NUCLEAR OPERATIONS GROUP – U. S. NUCLEAR REGULATORY COMMISSION INSPECTION REPORT 70-27/2015-007 AND NOTICE OF VIOLATION

Dear Mr. Burch:

This letter refers to the apparent violations that were identified during a routine, announced nuclear criticality safety (NCS) inspection conducted at your facility in Lynchburg, VA, from January 26 - 29, 2015. The details of the inspection are documented in Nuclear Regulatory Commission (NRC) Inspection Report 70-27/2015-006 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML15089A250).

In a letter dated March 30, 2015, we provided you with the opportunity to address the apparent violations identified in the report by attending a predecisional enforcement conference, by attending alternative dispute resolution (ADR), or by providing a written response before we made our final enforcement decision. In a letter dated May 8, 2015, you provided a written response to the two apparent violations. Your response acknowledged the two apparent violations, provided the cause of the violations, and described corrective actions taken to preclude recurrence. In your written response, your staff concluded that the violation involving the unanalyzed condition should be characterized at Severity Level IV, because the likelihood of criticality remained “highly unlikely” based on items relied on for safety (IROFS) from other accident sequences in your integrated safety analysis (ISA) and other non-IROFS controls. You also concluded that the second violation, involving the failure to submit a required report of an unanalyzed condition, should be characterized at Severity Level IV.

Based on the information developed during the inspection, subsequent communications, and the information that you provided in your response dated May 8, 2015, the NRC has determined that two violations of NRC requirements occurred. The violations are cited in Enclosure 1 Notice of Violation (Notice) and the circumstances surrounding them are described in detail in NRC Inspection Report 70-27/2015006. The first violation involves the failure to assure that clean-out activities performed in the low level dissolver (LLD) were subcritical under a credible abnormal condition, including use of an approved margin of subcriticality. The second violation involves the failure to submit a required report within 24 hours of an unanalyzed condition, which was discovered during clean-out activities of the LLD catch tray. You subsequently reported the unanalyzed condition on January 28, 2015 [NRC Event Notification 50776].

The first cited violation involves the failure to assure that clean-out activities performed in the LLD were subcritical under a credible abnormal condition, including use of an approved margin of subcriticality. This failure did not result in any actual consequences, as no criticality accident occurred. However, this is a significant concern to the NRC as it involved the failure to identify a credible pathway that could potentially lead to criticality and establish sufficient controls to assure subcriticality of an activity involving special nuclear material (SNM). As a result, an unanalyzed condition occurred on January 9, 2015, when recovery area operators performing clean-out activities in the LLD catch tray scraped uranium-bearing accumulations into an unfavorable configuration that had not been evaluated for nuclear criticality safety. In your written response, you acknowledged that an unanalyzed condition existed and identified two potential pathways to criticality in the LLD catch tray: (1) an acute introduction of material via a dissolver tray or filter bowl spill and (2) a chronic accumulation via small, incremental losses during processing. As you presented in your written response, measures were in place which served to limit the likelihood of criticality for both identified pathways. The NRC's assessment performed in accordance with inspection manual chapter (IMC) 2606 is provided in Enclosure 2 and is briefly summarized below.

For the acute pathway, the NRC acknowledges that the fixed location of the dissolver trays and filter bowls and the operator notification of the NCS staff in the event of a spill of greater than 2.5 liters were sufficient to limit the likelihood of criticality to "highly unlikely" per your integrated safety analysis (ISA) methodology. For the chronic pathway, the NRC acknowledges that the periodic nuclear material control (NMC) inventories and the administrative actions of the operator controlling the process served as barriers to limit the amount of uranic mass present in the catch tray. However, the NRC does not consider the free-drainage capability of the catch tray to be effective for all mechanisms of chronic accumulation. Specifically, the catch tray drains are not effective for solid accumulations such as those involved in the event that occurred on January 9, 2015. The NRC does not consider the catch tray drains to be sufficiently reliable to limit solid accumulations. Although the NRC acknowledges that the periodic NMC inventories and the administrative actions of the operator controlling the process represented barriers to limit mass and reduce the likelihood of a criticality, they were not sufficient barriers to limit the likelihood of criticality to "highly unlikely" at the time of the event per your ISA methodology. Giving consideration to these barriers, this violation was determined to align with an example in the NRC Enforcement Policy for the likelihood of a high-consequence event being "unlikely" based on your ISA. The NRC also noted that the operator's actions of collecting uranium-bearing material into piles appear indicative of a lack of understanding of NCS-related hazards. Operators are expected to have specific training on NCS hazards and to perform their assigned tasks with vigilance and safety consciousness. In this case, the operator performed actions that were outside procedural guidance which led to the unanalyzed condition. Therefore, this violation has been categorized in accordance with the NRC Enforcement Policy, Paragraph 6.2.c.1, as a Severity Level III violation.

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In accordance with the NRC Enforcement Policy, a base civil penalty in the amount of $35,000 is considered for a Severity Level III violation. Because your facility has not been the subject of escalated enforcement actions within the last two years, the NRC considered whether credit was warranted for *Corrective Action* in accordance with the civil penalty assessment process in Section 2.3.4 of the Enforcement Policy. As documented in your written response, the NRC recognizes that your immediate and long-term corrective actions included but were not limited to the following: (1) suspension of LLD clean-out activities until a safety basis was developed, (2) additional oversight to ensure that recent clean-out activities were performed safely, (3) development of an NCS analysis and revision to your ISA to include the acute and chronic accident sequences and explicitly credit the controls relied on to prevent occurrence, (4) development of a new item relied on for safety (IROFS) to use a radiation detection instrument to assay the LLD catch tray for mass accumulations, (5) a review of the process hazards analysis (PHA) process including a review of procedural guidance for performing PHAs and training requirements of PHA team members, (6) a review of several existing PHAs with special emphasis on the evaluation of maintenance activities, and (7) an extent of condition review to assess whether similar clean-out activities have an adequate safety basis. Although sufficient controls were not implemented at the time of the event to limit the likelihood of criticality to “highly unlikely” based on your ISA, your corrective actions and implementation of a new IROFS assure that the likelihood of criticality is now “highly unlikely.” Based on the above, the NRC determined that credit is warranted for your corrective actions regarding this violation.

Therefore, to encourage prompt comprehensive correction of violations, and in recognition of the absence of previous escalated enforcement action, I have been authorized, after consultation with the Director, Office of Enforcement, to propose that no civil penalty be assessed in this case. However, significant violations in the future could result in a civil penalty.

The second violation being cited is the failure to submit a required report of an unanalyzed condition discovered during clean-out activities of the LLD catch tray. This violation was determined to align with an example in the NRC Enforcement Policy for a failure to make a report as required by Appendix A to 10 CFR Part 70. Therefore, this violation has been categorized in accordance with the NRC Enforcement Policy, Paragraph 6.9.d.5, as a Severity Level IV violation.

In accordance with the NRC Enforcement Policy, Severity Level IV violations may be dispositioned as noncited violations. This violation is being cited in accordance with the NRC Enforcement Policy, Paragraph 2.3.2.b, because the NRC identified the unanalyzed condition and the required report was not submitted until after the NRC discussed this with your staff.

The NRC has concluded that information regarding (1) the reason for the violations, (2) the corrective actions that have been taken and the results achieved, and (3) the date when full compliance was achieved is already addressed on the docket in the letter from Babcock and Wilcox Nuclear Operations Group, Inc. dated May 8, 2015. Therefore, you are not required to respond to this letter unless the description therein 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.

In accordance with 10 CFR 2.390 of the NRC's "Agency Rules of Practice and Procedure," a copy of this letter, and its enclosure will be made available electronically for public inspection in the NRC Public Document Room and 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.

Thank you for your cooperation. If you have any questions, please contact Alan Blamey at (404) 997-4415.

Sincerely,

/RA/

Victor M. McCree
Regional Administrator

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

Enclosures:
1. Notice of Violation
2. Assessment of Risk from the Violation IMC 2606

cc: (see page 5)

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Sincerely,

/RA/

Victor M. McCree
Regional Administrator

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NOTICE OF VIOLATION

Babcock and Wilcox Nuclear Operations Group, Inc.
Lynchburg, VA

Docket No. 70-27
License No. SNM-42
EA-15-021

During an NRC inspection conducted on January 26 - 29, 2015, two violations of NRC requirements were identified. In accordance with the NRC Enforcement Policy, the violations are described below:

A. Title 10 of the *Code of Federal Regulations* (10 CFR) 70.61(a) requires, in part, that the licensee shall evaluate, in the integrated safety analysis performed in accordance with §70.62, its compliance with the performance requirements in paragraphs (b), (c), and (d) of this section.

   Section 70.61(d) requires, in part, that the risk of nuclear criticality accidents must be limited by assuring that under normal and credible abnormal conditions, all nuclear processes are subcritical, including use of an approved margin of subcriticality for safety.

   Contrary to the above, on or before January 9, 2015, the licensee failed to assure that under a credible abnormal condition, all nuclear processes were subcritical including use of an approved margin of subcriticality. Specifically, the licensee did not identify a credible abnormal condition that could potentially lead to a high consequence criticality event and did not establish sufficient controls to assure subcriticality of clean-out activities performed in the low level dissolver catch tray. An abnormal condition was created on January 9, 2015, when a recovery operator scraped the accumulated material in the low level dissolver catch tray into several piles creating a configuration that was not analyzed in the integrated safety analysis.

This is a Severity Level III violation (Section 6.2).

B. Appendix A (b) (1) of 10 CFR Part 70 requires, in part, a 24 hour report of any event or condition that results in the facility being in a state that was not analyzed, was improperly analyzed, or is different from that analyzed in the Integrated Safety Analysis, and which results in failing to meet the performance requirements of §70.61.

   Contrary to the above, on January 9, 2015, the licensee failed to report an event that resulted in the facility being in a state that was not analyzed and which resulted in a failure to meet the performance requirements of §70.61. Specifically, the licensee failed to report an unanalyzed condition that occurred during a clean-out activity of the low level dissolver catch tray.

This is a Severity Level IV violation (Section 6.9)

The NRC has concluded that information regarding the reason for the violations, the corrective actions taken and planned to correct the violations and prevent recurrence, and the date when full compliance was achieved, is already adequately addressed on the docket in your letter dated May 8, 2015. 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, EA 15-021", 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, within 30 days of the date of the letter transmitting this Notice of Violation (Notice).

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, 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 June, 2015.

Assessment of Risk from the Violation (IMC 2606 Paragraph 6)

In your written response dated May 8, 2015 (Agencywide Documents Access and Management System (ADAMS) Accession Nos. ML15139A048 and ML15147A040), you acknowledged that an unanalyzed condition existed and identified two potential pathways to criticality in the low level dissolver (LLD) catch tray: (1) an acute introduction of material via a dissolver tray or filter bowl spill and (2) a chronic accumulation via small, incremental losses during processing. As you presented, measures were in place which served to limit the likelihood of criticality for both identified pathways. The following paragraphs describe the risk informed assessment performed by the NRC in accordance with Inspection Manual Chapter (IMC) 2606.

Acute Accident Sequence

Your staff identified two controls to prevent a criticality for this sequence: (1) the fixed spacing of the process vessels (dissolver trays and filter bowls) and (2) operator control of net weight and concentration. For these controls, your staff assigned a [-3] for the Frequency of Initiating Event and a [2] for the Effectiveness of Protection, respectively. Your staff also identified that the operator is required by procedure to notify the nuclear criticality safety (NCS) staff of any spills exceeding 2.5 liters. Combining these controls in accordance with your integrated safety analysis (ISA) methodology, your staff concluded that the likelihood of criticality for this accident sequence was limited to “highly unlikely” (i.e.,[-5]<[-4]).

The NRC acknowledges that the fixed location of the dissolver trays and filter bowls provide a robust barrier to prevent a significant spill of material. This barrier is a designated item relied on for safety (IROFS) and is formally maintained by management measures (surveillances, audits, configuration management, records, etc.) to ensure that it is sufficiently available and reliable to perform its safety function. As previously discussed, your staff identified that the operator is required to notify NCS of any spill greater than 2.5 liters. You stated that the LLD operation would be shut down and NCS immediately notified in the event of an acute upset. Although a spill of a dissolver tray or filter bowl should be infrequent based on their fixed location (i.e., not routine), the operators are trained to make immediate notifications when unusual events occur and routinely do so. The NRC acknowledges that this provides a barrier to prevent the formation of an unsafe configuration in the event of a spill. This barrier is proceduralized, is maintained by management measures (training, procedures, audits, records, etc.), and involves an operator performing a routine task. Giving consideration to these barriers, the NRC agrees that the likelihood of criticality remained “highly unlikely” based on your ISA methodology for this accident sequence. Additionally, the NRC acknowledges that the controls on dry waste handling for collecting the materials into 2.5 liter containers during clean-out would provide additional defense-in-depth.

Chronic Accident Sequence

Your staff identified: (1) the catch tray is designed to be free draining to prevent significant accumulations of solution, (2) the dimensions of the catch tray limit material laterally, (3) the operator administratively limits the amount of material in the catch tray, and (4) periodic nuclear material control (NMC) inventories and clean-outs are performed. Combining these controls, your staff stated that material accumulations in the catch tray would be limited to 74.64 liters. For these controls, your staff assigned a [-2] for Frequency of Initiating Event based on the combination of operator control over the process limiting uranium introductions to the catch tray and the free drainage capability of the tray. Your staff assigned a [2] for Effectiveness of Protection for the NMC inventories and clean-outs. Combining these controls in accordance with your ISA methodology, your staff concluded that the likelihood of criticality for this accident sequence was limited to “highly unlikely” (i.e., [-4]).

As demonstrated by operational history and as you acknowledged in your written response, solution introductions are not the only mechanism for chronic accumulation. A significant amount of the chronic accumulation is solid material (not liquid). As demonstrated by the event on January 9, 2015, where multiple piles of solid accumulation were collected into an unfavorable geometric configuration, solid material is not necessarily free draining (i.e., solids will not necessarily spread out and drain like liquids would). Therefore, the NRC does not consider the catch tray drains to limit slab height as an effective control for solid accumulations. Your staff stated that the vertical dimension (i.e., z direction) is also administratively controlled by the “operator control over the process limits uranium introductions to the catch tray”. Although incremental material spills to the catch tray do occur routinely during processing, the spills should be relatively small based on the operator being cautious not to spill significant amounts during processing and manual transfer between process vessels.

In order to effectively control the volume of material (in this case to ≤ 74.64 liters), the NRC considers effective controls on all three dimensions (i.e., x, y, and z directions) necessary. Additionally, the NRC considers the least effective control on any one of the three dimensions to limit the overall effectiveness of a volume control. The NRC acknowledges that the lateral dimensions of the catch tray provide a barrier to limit accumulation for the lateral dimensions but does not consider the catch tray drains to be effective in limiting the slab height of accumulations. The NRC does, however, acknowledge that the administrative actions of the operator controlling the process (operator control over the process limits uranium introductions to the catch tray) are a barrier that limits the slab height of accumulations. Therefore, the NRC considers the combination of these controls (lateral dimensions of the catch tray combined with operator control over the process) to provide a single barrier to limit volume. The lateral dimensions of the catch tray are not a designated IROFS, but are maintained by management measures to a level consistent with designated controls (sureveillances, audits, configuration management, records, etc.) The operator’s control over the process is an IROFS, and is maintained by management measures (training, procedures, audits, records, etc.). As previously stated, the least effective control on any one of the three dimensions limits the overall effectiveness of a volume control. In this case, the vertical dimension (i.e., z direction) is the least effectively controlled dimension as it is controlled administratively. The NRC considers this barrier (combination of catch tray lateral dimensions and operator’s control over the process) to align with a [-1] per your ISA methodology for Frequency of Initiating Event as it involves “prevention by a trained operator performing a routine task.

The NRC acknowledges that the periodic nuclear material control (NMC) inventories provide a barrier to limit the amount of time (and therefore mass) that material is allowed to accumulate in the catch tray. The NMC inventories are part of the NMC programmatic element and provide reliable protection. Therefore, the NRC agrees that this barrier aligns with a [2] for Effectiveness of Protection per your ISA methodology as it involves “protection by…trained [personnel] performing a routine task.”

Combining the Frequency of Initiating Event with the Effectiveness of Protection indices results in this accident sequence being “unlikely” (i.e., [-1] – [2] = [-3] > [-4]) per your ISA risk assessment table.

Overall, the NRC considers mass to have been inadequately controlled at the time of the event. The NRC acknowledges that, for future operations, your newly implemented control (using a radiation detection instrument to assay the LLD catch tray for mass accumulations) is sufficient to limit the likelihood of this accident sequence to "highly unlikely" based on your ISA methodology. Additionally, the NRC acknowledges that the controls on dry waste handling for collecting the materials into 2.5 liter containers during clean-out would provide additional defense-in-depth.

<u>Additional Risk Mitigation</u>

In your written response, you stated that IMC 2606 Paragraph 06.04 allows for the reduction of likelihood one order of magnitude "if there is substantial margin such that an extreme or multiple failures would be needed beyond what is reasonable before an accident can occur." This is in regard to a likelihood matrix (Table 2) provided in IMC 2606 Paragraph 06.03. Paragraph 06.04 states, "[r]educe likelihood one order of magnitude (shift likelihood one cell to the left in Table 2), if there was substantial margin such that an extreme or multiple failures would be needed beyond what is reasonable to assume before an accident can occur."

The NRC acknowledges that multiple spills may be required to accumulate a critical mass due to chronic accumulation; however, the number of spills required is not known and multiple spills are expected as a normal case, not control failures. In order to reduce likelihood one order of magnitude, there must be "substantial margin such that an extreme or multiple *failures"* are needed to reach an unsafe condition. As you stated in your response, "[m]aterials are manually transferred from the dissolver trays to filters bowls by way of mobile containers, and at times filter media (i.e., Solka Floc) is manually transferred back to the dissolver trays for re-leaching. Operators also stir material in the dissolver trays and add and pack down Solka Floc into the filter bowls. Cleanout of process vessels is also a manual process. These manual activities lead to small, incremental losses to the catch tray." While multiple spills may be required to accumulate a critical mass in the catch tray, having multiple small, incremental spills is a normal condition, not multiple control failures. Therefore, the NRC does not consider there to be substantial margin such that an extreme or multiple failures would be needed to reach an unsafe condition. Furthermore, in order to reduce likelihood one order of magnitude, "extreme or multiple failures would be needed *beyond what is reasonable*." Because multiple incremental spills are expected as a normal condition, multiple spills resulting in a significant accumulation in the LLD catch tray could reasonably occur due to frequent operation of the LLD and common-mode failures such as a less skilled operator.

IMC 2606 Paragraph 06.05 states, "[i]n the instance that the licensee does not have an ISA or accident sequences in the safety basis, the [NRC] staff should utilize Table 2 as guidance." In this case, the accident sequences were not in the safety basis as it involved an unanalyzed condition. Therefore, in addition to performing an assessment in accordance with your ISA methodology, the NRC performed an assessment using Table 2 of IMC 2606. IMC 2606 Paragraph 06.06 states, "Table 2 suggests a relationship between the number and type of controls and respective likelihood." As discussed in previous sections of Enclosure 2, two administrative controls were identified and determined to be implemented to an acceptable level: (1) the operator's control over the process (the limiting factor on effectiveness of volume control) combined with the lateral dimensions of the catch tray and (2) the NMC clean-outs. Giving consideration to the two un-credited administrative controls, the likelihood aligns with Table 2 as "unlikely" as it involves two administrative controls. This is consistent with the likelihood determination performed in accordance with the licensee's ISA methodology of "unlikely".

Table 2
Likelihood Matrix

	Highly Unlikely	Unlikely	Not Unlikely
Based on event likelihood	Less than 10^{-5} per event per year	Between 10^{-4} and 10^{-5} per event per year	More than 10^{-4} per event per year
Based on in-place controls	Two controls, including at least one engineered (2 PECs[1], 2 AECs[2], one ADM[3] plus a PEC)	Two ADM controls, or a single PEC, or an AEC plus an ADM	No controls or lesser controls than for unlikely.

Notes for Table 2:
[1]PEC - passive engineered control
[2]AEC - active engineered control
[3]ADM - administrative control

Basis for the 20 gU^{235}/liter Bounding Assumption

Section IV of Special Nuclear Materials (SNM)-42 Chapter 5, Appendix (Design Criteria for Nuclear Criticality Safety) states:

> "[w]hen evaluating an SNM bearing system for criticality safety, each of these parameters will be assumed to be at its optimum condition (i.e., most reactive condition) unless specified and acceptable controls are implemented to limit the parameters to certain values…In the application of these methods, credit may be taken for certain manufacturing or process parameters as controls (e.g., physical process, chemical properties, etc.). When so utilized, this credit is predicated upon the following requirements:
>
> 1. The bounding assumptions are defined and limits established based upon established physical, chemical, or scientific principles and/or facility specific experimental data supported by operational history…."

In your written response, you stated that a 20 gU^{235}/liter bounding assumption was made in the establishment of the total cleanout volume limit, and that this was supported by historical data. The NRC does not consider historical data to be equivalent to "experimental data *supported* by operational history" because it does not experimentally bound a parameter's value within the process but instead offers a limited operational history of the parameter.

SNM-42 Chapter 5, Section 5.2 (Nuclear Criticality Safety Criteria) states:

> "The design of equipment and establishment of operating safety limits shall consider pertinent process conditions and known modes of failure. The most credible combination of fissile material density, H/X ratio, solution concentration, reflection, interaction, interspersed moderation, and measurement uncertainty are assumed before Nuclear Criticality Safety

> limits are established. Certain conditions may be deemed incredible if specifically excluded by experimental evidence or design considerations…."

As previously stated, the NRC does not consider operational history to be equivalent to experimental evidence. In terms of design considerations, you acknowledged that "process materials of initially low concentration can form higher concentration due to physical mechanisms such as evaporation and liquid run-off." Operators are allowed to add moderator to the accumulations to facilitate clean-out activities. The accumulations could be of various forms and concentrations. The prevention of material into the catch tray is based on administrative actions of the operators. Based on these factors, the NRC does not consider optimum concentration to be specifically excluded by design considerations.

In your written response, you provided an additional evaluation performed using optimal concentration. The NRC acknowledges that the above discussed controls (volume control by combination of operator control of the process and tray lateral dimensions and NMC clean-outs) would still be applicable to the chronic accident sequence when analysis is performed using optimum concentration vice the 20 gU^{235}/liter assumption. However, the margin to criticality is less when analysis is performed using optimum concentration as it requires less mass for criticality than at 20 gU^{235}/liter.