August 15, 2012

Mr. Roger P. Cochrane, General Manager
Babcock and Wilcox
Nuclear Operations Group, Inc.
P.O. Box 785
Lynchburg, VA 24505-0785

SUBJECT: INSPECTION REPORT NO. 70-027/2012-204 AND NOTICE OF VIOLATIONS

Dear Mr. Cochrane:

The U.S. Nuclear Regulatory Commission (NRC) conducted a routine, announced nuclear criticality safety (NCS) inspection at your facility in Lynchburg, Virginia, from July 16-19, 2012. The purpose of the inspection was to determine whether activities involving special nuclear material were conducted safely and in accordance with your license and regulatory requirements. Throughout the inspection, observations were discussed with your staff. An exit meeting was held on July 19, during which inspection observations and findings were discussed with your management and staff.

The inspection, which is described in the enclosure, focused on the most hazardous activities and plant conditions; the most important controls relied on for safety and their analytical basis; and the principal management measures for ensuring controls are available and reliable to perform their functions relied on for safety. The inspection consisted of analytical basis review, selective review of related procedures and records, examinations of relevant NCS-related equipment, interviews with NCS engineers and plant personnel, and facility walkdowns to observe plant conditions and activities related to safety basis assumptions and related NCS controls.

Based on the results of this inspection, NRC has determined that two Severity Level IV violations of NRC requirements occurred. The violations were evaluated in accordance with the NRC's Enforcement Policy included on the NRC's Web site at www.nrc.gov; select **About NRC**, **How We Regulate**, then select **Enforcement**, then select **Enforcement Policy**. The violations are being cited in the enclosed Notice of Violation (Notice), and the circumstances surrounding them are described in detail in the subject inspection report. These violations are being cited in the Notice because they involved multiple missed opportunities to identify, or were identified by NRC. The first violation being cited as a Severity Level IV is the failure to analyze the new configuration and update the safety documentation, during the change review for the larger bread pans in the Met Lab. The second violation being cited as a Severity Level IV is the failure to implement items relied on for safety doubly-encased pipes) as stated in criticality safety evaluations and the Integrated Safety Analyses (ISA) Summary for the Pharmacy and Shipping and Receiving areas.

You are required to respond to this letter and should follow the instructions specified in the enclosed Notice when preparing your response. NRC will use your response, in part, to determine whether further enforcement action is necessary to ensure compliance with regulatory requirements.

In accordance with Title 10 of the *Code of Federal Regulations* 2.390 of NRC's "Rules of Practice," a copy of this letter and the enclosure will be made publicly available in the public electronic reading room of the NRC's Agencywide Documents Access and Management System (ADAMS). ADAMS is accessible from the NRC Web site at http://www.nrc.gov/reading-rm/ADAMS.html.

If you have any questions concerning this report, please contact Christopher Tripp of my staff at (301) 492-3214, or via email to Christopher.Tripp@nrc.gov.

Sincerely,

/RA/ S. Whaley for

Thomas G. Hiltz, Chief
Technical Support Branch
Division of Fuel Cycle Safety
and Safeguards
Office of Nuclear Material Safety
and Safeguards

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

Enclosures:
1. Notice of Violations
2. Inspection Report 70-027/2012-204

cc: Tony England, B&WNOG

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NOTICE OF VIOLATION

Babcock and Wilcox Nuclear Operations Group, Inc. Docket No. 70-27
Lynchburg, VA License No. SNM-42

During the U.S. Nuclear Regulatory Commission's (NRC's) inspection conducted July 16-19, 2012, a violation of NRC requirements was identified. In accordance with the NRC's Enforcement Policy, the violation is listed below:

A. Title 10 of the *Code of Federal Regulations* (10 CFR) 70.72(a) states, in part, that the licensee shall establish a configuration management system, that "must assure the following are addressed prior to implementing any change: … (2) Impact of the change on safety and health… (6) The impacts or modifications to the integrated safety analysis, integrated safety analysis summary, or other safety program information, developed in accordance with § 70.62."

   Safety Condition No. S-1 of Special Nuclear Material (SNM) License No. 42 requires that material be used in accordance with the statements, representations, and conditions in the license application dated June 29, 2007, and supplements thereto.

   Section 11.1.3 of the License Application states, in part, that "Modifications or additions to the facilities, processes, and equipment, used for handling, processing, or storing licensed material, shall be evaluated and approved following an approved procedure before the change is made and the ISA Summary is modified. Examples of changes that require evaluation and approval include: … A change that adds, alters, or removes IROFS."

   Contrary to the above, on December 9, 2009, the licensee failed to evaluate a change to equipment used to store licensed material that altered and effectively removed an item relied on for safety (IROFS). Specifically, during the nuclear criticality safety (NCS) change review for the new, larger 'bread pans' in the Met Lab the licensee failed to identify that the change would result in exceeding the volume limit for the Met Lab Fuel Storage Cabinets. The NCS review approved the change without an NCS evaluation; as a result, the facility change was not included in the ISA Summary annual update.

This is a Severity Level IV Violation (Supplement 6.2).

B. Safety Condition S-1 of SNM License No. 42 requires that material be used in accordance with the statements, representations, and conditions in the license application dated July 29, 2007, and supplements thereto.

   Title 10 CFR 70.61(e) states: "Each engineered or administrative control or control system necessary to comply with paragraphs (b), (c), or (d) of this section shall be designated as an item relied on for safety. The safety program, established and maintained pursuant to § 70.62 of this subpart, shall ensure that each item relied on for safety will be available and reliable to perform its intended function when needed and in the context of the performance requirements of this section."

   Title 10 CFR 70.62(d) states, in part: "Each applicant or licensee shall establish management measures to ensure compliance with the performance requirements of § 70.61…The management measures shall ensure that engineered and administrative

controls and control systems that are identified as items relied on for safety pursuant to § 70.61(e) of this subpart are designed, implemented, and maintained, as necessary, to ensure they are available and reliable to perform their functions when needed, to comply with the performance requirements of § 70.61 of this subpart."

Title 10 CFR 70.4 states, in part: "Management measures mean the functions performed by the licensee, generally on a continuing basis, that are applied to items relied on for safety, to ensure the items are available and reliable to perform their functions when needed. Management measures include configuration management…."

Contrary to the above, as of July 19, 2012, the licensee failed to maintain IROFS as established in the ISA. Specifically, items relied on for safety consisting of doubly-encased pipes in the Pharmacy and Shipping and Receiving areas were not implemented as stated in criticality safety evaluations and the ISA Summary.

This is a Severity Level IV Violation (Supplement 6.2).

Pursuant to the provisions of 10 CFR 2.201, Babcock and Wilcox Nuclear Operations Group, Inc., is hereby required to submit a written statement or explanation to the U.S. Nuclear Regulatory Commission, ATTN: Document Control Desk, Washington, DC 20555; with copies to the Chief, Technical Support Branch, Division of Fuel Cycle Safety and Safeguards, Office of Nuclear Material Safety and Safeguards; and Regional Administrator, Region II, within 30 days of the date of the letter transmitting this Notice. This reply should be clearly marked as a "Reply to a Notice of Violation" and should include: (1) the reason for the violation, or, if contested, the basis for disputing the violation; (2) the corrective steps that have been taken and the results achieved; (3) the corrective steps that will be taken to avoid further violations; and (4) the date when full compliance will be achieved. Your response may reference or include previously docketed correspondence if the correspondence adequately addresses the required response. If an adequate reply is not received within the time specified in this Notice, an Order or Demand for Information may be issued as to why the license should not be modified, suspended, or revoked, or why such other actions as may be proper should not be taken. Where good cause is shown, consideration will be given to extending the response time.

If you contest this enforcement action, you should also provide a copy of your response to the Director, Office of Enforcement, U.S. Nuclear Regulatory Commission, Washington, DC 20555-0001.

Because your response will be made available electronically for public inspection in the NRC Public Document Room, or from the NRC's document system, accessible from the NRC Web site at http://www.nrc.gov/reading-rm/adams.html, to the extent possible, it should not include any personal privacy, proprietary, or safeguards information so that it can be made available to the public without redaction. If personal privacy or proprietary information is necessary to provide an acceptable response, then please provide a bracketed copy of your response that identifies the information that should be protected and a redacted copy of your response that deletes such information. If you request withholding of such material, you must specifically identify the portions of your response that you seek to have withheld, and provide in detail the bases for your claim of withholding (e.g., explain why the disclosure of information will create an unwarranted invasion of personal privacy or provide the information required by

10 CFR 2.790(b) to support a request for withholding confidential commercial or financial information). If safeguards information is necessary to provide an acceptable response, please provide the level of protection described in 10 CFR 73.21.

Dated this 15th day of August 2012

U. S. NUCLEAR REGULATORY COMMISSION
OFFICE OF NUCLEAR MATERIAL SAFETY AND SAFEGUARDS

DOCKET NO.:	70-27
LICENSE NO.:	SNM-42
REPORT NO.:	70-27/2012-204
LICENSEE:	Babcock and Wilcox Nuclear Operations Group, Inc.
LOCATION:	Lynchburg, VA
INSPECTION DATES:	July 16-19, 2012
INSPECTORS:	Christopher Tripp, Senior Criticality Safety Inspector Timothy Sippel, Criticality Safety Inspector
APPROVED BY:	Thomas G. Hiltz, Chief Technical Support Branch Division of Fuel Cycle Safety and Safeguards Office of Nuclear Material Safety and Safeguards

EXECUTIVE SUMMARY

BABCOCK AND WILCOX NUCLEAR OPERATIONS GROUP, INC.
U.S. NUCLEAR REGULATORY COMMISSION INSPECTION REPORT 70-27/2012-204

Introduction

Staff of the U.S. Nuclear Regulatory Commission (NRC) performed a routine, announced nuclear criticality safety (NCS) inspection of the Babcock and Wilcox Nuclear Operations Group (B&WNOG or licensee), Inc.'s, facility in Lynchburg, Virginia, from July 16-19, 2012. The inspection included an onsite review of the licensee's NCS program, NCS evaluations, NCS audits, internal NCS event review and follow-up, criticality accident alarm system, plant operations, and open items review. The inspection focused on risk-significant fissile material processing activities and areas—including the Research Test Reactor and Target area, the Specialty Fuels Facility, and the Lynchburg Technology Center.

Results

- No safety concerns were identified regarding the licensee's NCS program.

- A Severity Level IV violation and an Unresolved Item (URI) were identified during review of the NCS event review and follow-up concerning changes made to the "bread pans" in the Met Lab. The violation concerned the failure to properly evaluate and document a change to the volume of "bread pans" used to store fissile material in the Met Lab Fuel Storage Cabinets. The URI concerned the implementation of the "permitted as necessary" administrative control on interspersed moderation without the establishment of specific limits, and the adequacy of the control given modeling assumptions. An unrelated Inspector Follow-Up Item (IFI) was also identified that tracks corrective actions and design changes related to an accumulation of uranium in a pump system.

- No safety concerns were identified regarding NCS audits.

- No safety concerns were identified during a review of the licensee's criticality accident alarm system.

- A Severity Level IV violation was identified during review of URI-2012-202-01. The violation concerned the failure to maintain doubly-encased piping in the Pharmacy and Shipping and Receiving areas as required by the Integrated Safety Analysis (ISA) Summary.

REPORT DETAILS

1.0 Summary of Plant Status

B&WNOG manufactures high-enriched uranium fuel, reactor core components and reactor cores at its facility near Lynchburg, VA. During the inspection, the licensee conducted routine fuel manufacturing operations and maintenance activities in the fuel fabrication and uranium recovery areas.

2.0 Nuclear Criticality Safety Program (IP 88015 & 88016)

a. Inspection Scope

The inspectors reviewed the licensee's NCS program and analyses. The inspectors evaluated the adequacy of the program and analyses to assure the safety of fissile material operations. The inspectors reviewed selected nuclear criticality safety evaluations (NCSEs) to determine that criticality safety of risk-significant operations was assured through engineered and administrative controls with adequate safety margin and prepared and review by qualified staff. The inspectors interviewed the licensee's managers and engineers, and selected operators. The inspectors reviewed selected NCS-related items relied on for safety (IROFS) to determine if the performance requirements have been met for selected accident sequences. The inspectors accompanied NCS and other technical staff on walkdowns of NCS controls in selected plant areas. The inspectors reviewed selected aspects of the following documents:

- NCS-2010-133, "NCS Safety Analysis for SER 10-047 Phase 01, 'Update NR Rack-010' (U)," January 18, 2011.
- NCS-2010-261, "NCS Safety Analysis for SER 10-049 Phase 01, 'Approval of 10 Location 2.5 Liter Rack with Poison,'" December 15, 2010.
- NCS-2011-054, "Revised NCS Safety Analysis for SER 10-047 Phase 01, 'Update NR Rack-010' (U)," March 17, 2011.
- NCS-2011-172, "Nuclear Safety Release for SER 11-024 Phase I – Annular Organic Tank – Pre-Operational Requirements," dated April 11, 2012.
- NCS-2012-078, "NCS Justification Analysis to Extend Temporary NCS Posting TEMPORARY-255," dated May 17, 2012.
- NCS-2012-101, "Safety Concern Analysis for Standard Mass Violation in Bay 8A of Standards Rack – CA201201860," dated June 25, 2012.
- QWI-5.1.12, "Change Management," Rev. 23, March 6, 2012.

b. Observations and Findings

The inspectors observed that the licensee had an NCS program which was independent from production and was implemented through written procedures. The inspectors also observed that the licensee's NCS program reviewed process changes affecting criticality safety. All change requests (CR) that impact special nuclear material are routed to NCS. The CR is assigned to a qualified NCS engineer or manager for review. The NCS engineer uses his training, experience, and technical judgment to review the CR against a list of criteria. If one or more of the criteria are satisfied, the NCS engineer sends the CR back with a comment that a Safety Evaluation Request (SER) is required for that

change. Staff observed that the process for reviewing CRs is not well defined in procedures, as much is left up to the judgment of the reviewer; and the procedure merely requires a check-list approach by a single analyst. This may have contributed to the failure to properly evaluate and document a change to the volume of "bread pans," which is discussed below.

The inspectors reviewed selected NCS Approvals, NCS Analyses, and supporting calculations for selected operations with fissile material. For the analyses reviewed, the inspectors determined that the analyses were performed by qualified NCS engineers; and that quality assurance reviews of the evaluations were completed by qualified NCS engineers. The analyses generally provided for the subcriticality of the systems and operations with an approved margin of subcriticality through appropriate limits on controlled parameters (an exception discussed below), and double contingency was assured for each credible accident sequence leading to inadvertent criticality that was selected for review. The inspectors reviewed selected IROFS supporting NCS controls and determined that the IROFS corresponded to the approved analytical results and designated controls, and were adequate to meet performance requirements for the selected accident sequences (with the exception discussed below). NCS analyses and supporting calculations demonstrated adequate identification and control of NCS hazards to assure operations within subcritical limits.

c. Conclusions

The inspectors identified a weakness in the CR review process that may have contributed to the failure to properly evaluate and document a change to the volume of "bread pans," which is discussed below. No other safety concerns were identified regarding development, review, or approval of NCS analysis or calculations or resulting NCS controls.

3.0 Nuclear Criticality Safety Inspections, Audits, and Investigations (IP 88015)

a. Inspection Scope

The inspectors reviewed the licensee's internal audit and NCS inspection procedures, and results of the most recent NCS quarterly audit to assure that appropriate issues were identified and resolved. The inspectors accompanied a licensed NCS engineer on a routine internal NCS inspection of the Supercompactor. The inspectors reviewed selected aspects of the following documents:

- NCSE-03, Rev. 21, "Nuclear Criticality Safety Audits and Inspections," November 7, 2005.
- NCS-2012-051, "NCS Violation & Observation Summary – 1st Quarter 2012," April 26, 2012.

b. Observations and Findings

The inspectors observed that the licensee's NCS audits were conducted in accordance with written procedures (NCSE-03). The inspectors noted that audits were performed by NCS engineers who reviewed operations for control adequacy and compliance with the license requirements, including procedures and postings, and examined equipment to

ensure that the evaluated configuration remained valid. The engineers also reviewed NCS issues from previous audits, reviewed new violations during the past audit quarter, analyzed violations for possible trends, and confirmed that any violations were appropriately addressed and resolved by the Corrective Action Program (CAP).

The inspectors reviewed the most recent audit report (NCS-2012-051) covering first quarter of 2012, focusing on the 10 new Level II findings identified in the first quarter. Level II findings are those which constitute regulatory or procedural non-compliances. There were no Level I findings in the first quarter which represent an "imminent threat" to health and safety. The inspector reviewed the list of findings and their referral to the CAP and did not identify any concerns.

The inspectors accompanied an engineer on a weekly inspection of the Supercompactor area. The inspectors noted the use of an "NCS Quarterly Audit Checklist," which lists all plant areas to be inspected twice annually—either in the first and third or second and fourth quarters. During the inspection of the Supercompactor, the auditor questioned the operators on the conduct of the operation and the NCS limits and controls, observed the equipment in operation, inquired about recent activities, and observed the storage of drums. The auditor stated that before the inspection, he had reviewed NCS evaluations, procedures, and postings. The inspector also questioned operators about operational aspects such as how they react to spills and how mass limits in material placed into the overpacks are controlled. The operators were knowledgeable about the conduct of their operations and the applicable limits and controls. Criticality safety is ensured by limiting the amount of material in a 55-gallon drum or an 80-gallon overpack to 100 grams Uranium-235 (^{235}U). Drums are handled individually in the Supercompactor area and are not stacked. Mass is tracked by the computer and operations automatically halted if the mass limits are exceeded. The inspector noted that the weekly inspection was thorough and was performed at an appropriate level for the complexity of operations. No findings were identified during the weekly inspection.

c. Conclusions

No safety concerns were identified regarding NCS audits.

4.0 Nuclear Criticality Safety Event Review and Follow-Up (IP 88015 & 88016)

a. Inspection Scope

The inspectors reviewed the licensee's response to a selection of recent internally reported events, and Event Notice (EN) 48091 that the licensee reported to NRC on July 11, 2012. The inspectors reviewed the progress of investigations and interviewed the licensee's staff regarding immediate- and long-term corrective actions. The inspectors reviewed selected aspects of the following documents:

- [Correction Action] CA 201201757, May 31, 2012.
- CR-1032470, "Replace Sample Holder Bread Trays with New Perforated Holders," Rev 00, December 7, 2009.
- ISA Summary, Table 15.28.4.1.1, "Met Lab Fuel Storage Cabinets."

- NCS-05, “Moderation Control,” Rev 6, August 15, 2011, of “Nuclear Criticality Safety Manual,” Rev 7.
- NCS-2010-234, “Safety Concern Analysis for Extra Mass Placed in Bread Pan (CA201000291),” February 11, 2010.
- NCS-2011-079, “NCS Safety Analysis to Support RTRT AFIP-6 Mark II UMo Fabrication per SER 11-010 Phase 1,” April 26, 2011.
- NCS-2011-229, “Safety Concern Analysis for Extra Mass Placed in Bread Pan (CA201103660),” December 20, 2011.
- NCS-2012-062, “Safety Concern Analysis for Placing Fuel Elements on a Non-Fuel Cart (CA201201256),” April 26, 2012.
- NCS-2012-078, “NCS Justification Analysis to Extend Temporary NCS Posting TEMPORARY-255,” May 17, 2012.
- NCS-2012-094, “Safety Concern Analysis for Uranium Detected In RTR Arc Melt Vacuum Pump System – CA-201201757,” June 18, 2012.
- NCS-2012-108, “Safety Concern Analysis for Bread Pans Exceeding Evaluated Dimensions for Met Lab Fuel Storage Cabinets (CA20120197),” July 14, 2012.
- NCS-2012-118, “Safety Concern Analysis for Bread Pans Exceeding Evaluated Dimensions for Met Lab Fuel Storage Cabinets (CA201201973) Revised,” July 26, 2012.

b. Observations and Findings

The inspectors reviewed EN 48091, an NRC-reportable event, and selected licensee internally reported events and corrective actions.

In one recent event, a small amount of uranium was found to have accumulated in the Research and Test Reactor (RTR) Arc Melt Vacuum Pump System. The uranium was discovered by radiation protection personnel during maintenance on a broken pump. NCS personnel were notified when the uranium was detected. The licensee determined that the total amount of uranium in the system was about 17.5 grams, which had accumulated over the last
27 years. About 0.02 grams of uranium were detected in the pump oil. There were no IROFS in place to prevent uranium accumulation or prevent a criticality, and this system had not been analyzed for a criticality concern by NCS. However, the licensee considered a criticality to be incredible due to the favorable geometry of the pump and the extremely slow rate of accumulation. The licensee is tracking this as CA-201201757. The licensee’s short-term corrective actions included removing similar pumps from service. The licensee is evaluating long-term corrective actions, including possible design changes. The NRC is opening **IFI 70-27/2012-204-01** to track the licensee’s long-term corrective actions and potential design changes to the RTR Arc Melt Vacuum Pump System.

The inspectors determined that the licensee adequately evaluated whether these events were reportable to the NRC. The inspectors observed that internal events were investigated in accordance with written procedures and appropriate corrective actions were assigned and tracked.

Met Lab Fuel Storage Cabinet Event

On July 10, 2012, during the most recent routine NCS quarterly audit, the licensee's NCS engineers's auditing controls and NCS analyses in the Met Lab identified that the "bread pans" used only in the Met Lab exceeded the criticality safety volume limit for bread pans in the Met Lab Fuel Storage Cabinets (referred to as storage cabinets hereafter). The storage cabinets are the only storage location in the Met Lab with a volume limit for the bread pans. The volume limit, of 2.5 liters (L), is credited as an IROFS in the ISA. On July 11, 2012, the event was reported to the NRC under the requirements of Title 10 of the *Code of Federal Regulations* (10 CFR) 70, Appendix A (b)(1), as an unanalyzed condition. Given the larger volume bread pans (about 5.68 L), a worst-case loss of moderator control was initially evaluated as resulting in a k_{eff} of 0.9964; including adjustments for bias, bias uncertainty, and calculated k_{eff} uncertainty, when modeled according to the methodology specified in the license.

The inspectors reviewed the event during the inspection. Historically, the licensee had used 2.5 L bread pans in the Met Lab to store fuel samples. This was the configuration analyzed in the ISA and described in the ISA Summary provided to the NRC. The licensee imposed a suite of IROFS to meet the performance requirements, and used the conservative methods specified in the license to analyze the potential for a criticality event. These IROFS included an administrative limit on the mass of ^{235}U of 350 grams per storage location; an administrative limit of one container with a volume less than 2.5 L per storage location; administrative and engineered (the cabinet is an IROFS) limits on spacing (at least 12-inch, edge-to-edge spacing); and an administrative limit on moderation. The posting (NRRACK-03, Rev. 06, 11/28/00, NCS-2000-374) states: "Moderating materials are permitted between storage units only as necessary for normal operations." Guidance on what is "necessary" is contained in the "Nuclear Criticality Safety Manual." Chapter NCS-05, on "Moderation Control," discusses the "permitted as necessary" limit. This type of moderation control is applicable to operations that will not become critical with the addition of moderator alone (i.e., k_{eff} is below 0.95 for optimum moderation). Chapter NCS-05 also provides examples of acceptable uses of moderating material. The inspectors observed that excessive amounts of moderating material were not present in the Met Lab or other areas that the inspectors walked down.

On December 7, 2009, CR 1032470 was initiated to replace the old 2.5 L bread pans with larger perforated bread pans. This change was approved by NCS personnel on December 9, and implemented in early 2010, after the new bread pans were fabricated. The NCS review of the CR failed to identify that the change would result in exceeding the volume limit for the storage cabinets. The NCS review failed to identify the change as requiring an SER which would trigger an NCS analysis of the new configuration, including establishing limits for controls/IROFS to demonstrate subcriticality with an approved margin, as well updating the ISA and ISA Summary as needed. This NCS failure during the change process to analyze the new configuration and update the safety documentation before approving the change is **Violation (VIO) 70-27/2012-204-02**.

Given the loss of the control on volume, the inspectors reviewed the adequacy of the remaining controls. The principal controls remaining were the administrative controls on mass and moderator. The other remaining controls were the administrative and

engineered controls on spacing. The control on mass relies on accurate mass values being associated with each sample. The mass of the ^{235}U in the samples is measured by Nuclear Materials Control which relays the values to the Met Lab. The mass of ^{235}U in the bread pan is tracked by a mass log that is kept with the bread pan. The licensee uses the mass log to track the amount of ^{235}U in each bread pan by adding and subtracting the ^{235}U mass of each sample when it is added or removed. There are two limits for the mass of ^{235}U; the 350 gram limit is the Routine Operating Limit (ROL). The other limit is the Limiting Condition of Operation (LCO), which is the mass of ^{235}U for which the Safety Limit (k_{eff} = 0.95) is met. For the storage cabinets, this limit was set at 400 grams. The ROL is set lower than the LCO to account for measurement uncertainty and normal process variability. However, these limits were set assuming the volume was limited to 2.5 L; and new limits on controlled parameters were not evaluated as a result of the failure to analyze the new configuration.

When the licensee discovered that the bread pans in the Met Lab exceeded the volume limit in the storage cabinets, they performed an analysis to show that a 250-gram limit would allow "safe shutdown" of the storage cabinets. At the time of discovery, two bread pans contained more than 250 grams of ^{235}U. The excess material was moved to other bread pans so that all bread pans would be less than 250 grams. The inspectors reviewed the licensee's analysis in NCS-2012-108 and confirmed that the licensee was able to achieve a safe configuration with the 250-gram limit, relying only on the remaining IROFS, modeling the configuration according to the methodology in the license, and assuming a worst-case, single upset. Administrative restrictions were placed on the cabinets: no additional fissile material may be transferred in; material was only allowed to be transferred out. In addition, an NCS engineer was required to be present whenever the cabinets were opened. During walkdowns, the inspectors observed these restrictions in effect and noted that much of the material had been removed. The licensee confirmed that in the days since the event was discovered, much of the material had been moved to the "NR-010" storage racks; so that Met Lab operations could continue safely. The NR-010 storage racks are approved for storage of up to five-gallon buckets, which bounds the volume of either size bread pans. The inspectors reviewed the corrective actions associated with the event. The inspectors determined that the licensee staff had taken adequate and prompt corrective actions to achieve "safe shutdown."

The criticality methodology used to model the configurations, and calculate k_{eff} is also used to evaluate which NCS IROFS are needed and to evaluate the effectiveness of NCS IROFS. The methodology used is specified in the license. Two aspects of the methodology that particularly impact the significance of this event are the 'moderator sweep' and the "Law of Substitution." The 'moderator sweep' is the practice of evaluating moderator upsets as the configuration being fully flooded with water at the density that results in the highest k_{eff}. This upset condition is referred to as optimum moderation because the k_{eff} due to moderation has been optimized. The optimum moderation is typically determined by evaluating a range of water densities between zero and full-density water. The 'Law of Substitution' is a technique for bounding neutron interaction for systems that are not neutronically isolated from one another. The effect of applying it to the storage racks was that the x and y boundaries of the configuration were modeled with a 'reflective' or 'mirror' boundary condition. This causes any neutrons that exit the model through the x and y boundaries to be 'bounced'

back in. This modeling practice increases the resulting k_{eff} of the model which is intended to bound the effect of fissile material located outside the model.
The licensee is also required to set limits on controlled parameters for criticality safety purposes. The limits in this case are the ROL and LCO values. The LCO value is set such that any single failure in the controlled parameter will not exceed the Safety Limit value (the value at which k_{eff} = 0.95) for that parameter. Also, under normal conditions the system k_{eff} is to be maintained at or below 0.92. However, for the moderator control the licensee did not initially determine what these values were, or show how moderator was limited to below these values. As mentioned above, the posting and control permitted moderator "as necessary," but did not provide ROL and LCO limits. Because the initial calculations assumed the presence of the volume control, no amount of moderation would result in a k_{eff} above 0.92, so these limits were not needed. After the loss of volume control was discovered, the licensee performed an analysis (NCS-2012-108) of the system using the 'Law of Substitution.' For moderator upsets, the license requires that "[c]alculations to determine the accident condition k-effective is based on optimum moderation unless moderating materials such as polyethylene, water, and paper are restricted or carefully controlled." Because the "permitted as necessary" control does not meet the "restricted or carefully controlled" clause, optimum moderation was modeled; and was the worst-case single upset in NCS-2012-108. The new bread pans were in place for over two years with the original limit of 350 grams in force. So all bread pans were assumed to be optimally moderated and contain 350 grams of ^{235}U, which results in an adjusted k_{eff} of 0.9964 and exceeds the Safety Limit of 0.95. As a result, the licensee notified the NRC of the event.

The inspectors questioned the licensee about the effectiveness of the "as necessary" moderator control, given the presence of plastic and similar synthetic moderators in and around the storage cabinets. To address these questions, the licensee performed a revised analysis (NCS-2012-118) of the system. This analysis was performed and sent to the NRC after the exit meeting. The analysis considered polyethylene (plastic) in the storage cabinets. However, the analysis didn't appear to consider polyethylene in other credible locations, such as near the cabinets. The analysis shows that mixtures of polyethylene and water are bounded by the optimum moderation. The licensee's analysis of polyethylene in the cabinets does not exceed the 0.92 limit without the presence of water, even when the 'Law of Substitution' is applied.

The licensee also analyzed the storage cabinets using an alternate method of accounting for neutron interaction, which can be applied to neutronically isolated units. Until questions from the inspectors lead to the revised analysis, the licensee had not recognized that the license permitted another method of modeling neutron interaction by surrounding a unit in 12 inches of water reflector. This method is discussed in Section 5.2.2 of the license, which states that: "Individual fuel units which are safe by themselves must be evaluated to determine the extent of the neutron interaction between other fuel units in an array. Units will be considered isolated from each other if the increase in K-effective of a unit, due to the presence of another fuel unit, is equal to or less than a K-effective when the presence of an identical unit is separated from the first by twelve inches of water." As worded, this is not clear as it is comparing "the increase in K-effective" to "K-effective." It also is not clear how this should be applied. An example of how the licensee modeled the "unit" and the "12 inches of water," is shown below (adapted from NCS-2012-118, Figure 6). The unit was modeled as being composed of the bread pans in a cabinet (the A blocks), a bread pan in-transit (B block), a bread pan

outside of the room (C block), and a 350 gram ^{235}U unit (the yellow block) to account for material in a nearby room. A reflective boundary condition was applied (the pink face of the model) so that the unit includes 'a mirror image' of the same configuration for the other cabinet. The unit was placed on a concrete floor (blue material) and surrounded by 12 inches of water (green material).

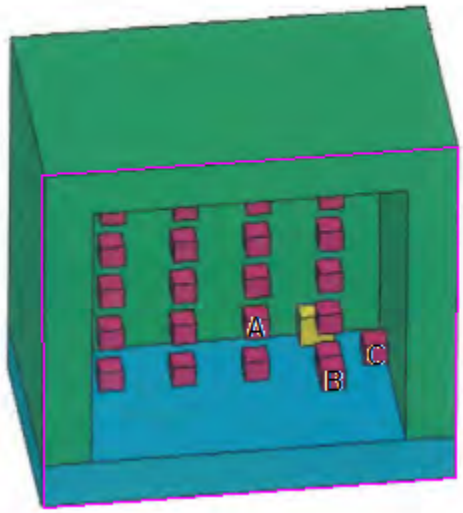

Figure 1: Model of Unit Surrounded by 12 Inches of Water

With this alternate method of modeling interaction, the new bread pan design would still meet the Safety Limit because the worst-case upset would not exceed the 0.95 limit. In addition, the normal case is below 0.92. Therefore, the licensee retracted the EN on August 6, 2012.

Because questions have been raised about the meaning of license commitments and because a more widespread review of the use of "permitted as necessary" controls is warranted, this will be treated as an URI. **URI 70-27/2012-204-03** tracks the implementation of the "permitted as necessary" administrative control on interspersed moderation without the establishment of specific limits, and the adequacy of the control, given modeling assumptions.

c. Conclusions

A weakness was identified regarding the controls and evaluations of the RTR Arc Melt Vacuum Pump System.

A Severity Level IV violation was identified regarding the failure during the change process to analyze the new configuration and update the safety documentation before approving the change.

An URI was identified regarding the implementation of the "permitted as necessary" administrative control on interspersed moderation without the establishment of specific limits and the adequacy of the control, given modeling assumptions.

No other safety concerns were identified regarding the licensee's identification of NCS-related events, and corrective actions were adequately tracked by the licensee.

5.0 Criticality Alarm Systems (IP 88017)

a. Inspection Scope

The inspectors reviewed documentation of criticality accident alarm detector coverage, and interviewed engineering staff to determine the adequacy of the licensee's new criticality alarm system. The licensee's criticality alarm system is referred to as Criticality Incident Detection Alarm System (CIDAS). The inspectors reviewed selected aspects of DOC-29018, Issue B, "Factory Acceptance Test: B&W CIDAS."

b. Observations and Findings

The inspectors discussed the status of the facility's criticality accident alarm system with the cognizant licensee's NCS engineer. The current system is no longer supported by the manufacturer and a new, modern system is being implemented. New analyses are being performed to determine the location of the detectors (per ANS-8.3) using the MAVRIC module in the SCALE code package rather than MCNP as used in the past. The advantage of using MAVRIC is that it generates maps showing detector response (e.g., dose rates) over a wide area rather than at selected tally points. The licensee's NCS engineer responsible for the analysis stated that the new system is being implemented in phases and has already been installed in one area of the facility. The inspectors reviewed the acceptance testing for this area, which has been completed for one of two panels to be installed. The acceptance testing document contains multiple functional tests related to detector response against the criteria of 10 CFR 70.24 and ANSI/ANS-8.3. The licensee's NCS engineer indicated that adequate spare parts are on hand to maintain the old system until the new system is fully implemented. The new system is expected to be implemented in the rest of the facility by the end of 2013.

The new system is expected to have a greater reliability, especially in terms of greater resistance to lighting strikes, and less susceptibility to false alarms (due to a higher detector threshold and revised alarm logic). The licensee is also considering and addressing other areas such as: improving the error checking and diagnostic features of the system and the needs of emergency response personnel after a potential criticality event.

c. Conclusions

No safety concerns were identified during review of the licensee's new criticality accident alarm system.

6.0 Open Item Review

URI 70-27/2012-202-01

This item tracks the licensee's review of the safety basis and extent of condition for doubly-encased water piping in moderation controlled areas. During a previous inspection, the inspectors observed that "building design" is credited as an IROFS for moderation control in SAR 15.32 (Pharmacy operations), which includes a requirement that water lines be doubly-encased. However, the licensee could not verify that all water lines in the area met this condition. The licensee stated that the building design was not

relied on to meet the performance requirements because it was not included in the minimum protection score.

During the current inspection, the inspectors reviewed the licensee's extent of condition report, NCS-2012-045, "Extent of Condition Review for Commitment 38804(U)," dated April 30, 2012. The licensee determined that some of the water pipes in the Pharmacy area (SAR 15.32) were not in fact doubly-encased (CA 201200690). In addition, the extent of condition review indicated that some pipes in the Shipping and Receiving area (SAR 15.30) were also not doubly-encased (CA 201201335). The inspectors determined that the licensee had evaluated the safety impact of not having the doubly-encased piping in these areas in NCS-2012-063, "NCS Safety Analysis Revising the Safety Basis of the Filler Area Fuel Transport Cart per CR-1038349(U)," dated May 16, 2012; and NCS-2012-099, "NCS Safety Analysis for CR-1038741, 'Changes to IROFS in SAR 15.30, Shipping and Receiving Area Worktables (U),'" dated June 27, 2012. The original SAR tables credited two IROFS associated with building piping, one described generally as "building design" and the other specifically requiring that "water lines in area are double encapsulated." The licensee pointed out that neither of these was credited as part of the minimum protection score and therefore not required to meet the performance requirements. In addition, the "building design" IROFS is implemented in QWI 4.1.5, Rev. 13, Attachment 3. "Nuclear Criticality Safety Engineering Design Criteria & Guidelines," which states that "areas under moderation control <u>should</u> provide that all water and steam lines are either left out by design, disconnected and plugged, double-cased, or shielded" [emphasis in original]. Because QWI 4.1.5 expresses this design criterion as a recommendation ("should"), it should not be viewed as an essential part of the "building design" IROFS. Moreover, the licensee provided the inspectors with documentation showing that the original requirement was described as "integrity of the water lines" (NCS-2001-043, "Level 2 NCS Evaluation for SER 01-006, 'Receipt of Uranium Metal—Phase 1—6M Shipping Container,'" dated February 9, 2001) and that double-encased piping was not needed to meet the double contingency principle (NCS-1993-161, "NCS Evaluation Opening Moderation Controlled Containers Outside Mod Controlled Areas," dated November 4, 1993).

The inspectors reviewed the aforementioned documents and determined that, while QWI 4.1.5 does not necessarily require doubly-encased piping—which is the approach relied on in SARs 15.30 and 15.32 rather than measures such as total exclusion, plugging, or shelding—because the SAR tables specifically call out doubly-encased piping as part of the IROFS description. The licensee's failure to implement and maintain these IROFS as part of the configuration of its building design is **VIO 70-27/2012-204-04**; URI-70-27/2012-202-01 is closed to VIO 70-27/2012-204-05.

The inspectors noted that the licensee has revised its safety basis to remove reliance on doubly-encased piping in these areas. The safety significance of the failure to maintain the building configuration is low because the licensee demonstrated that these IROFS are not needed for double contingency and, therefore, are considered defense-in-depth. It is also true that these IROFS were not used in deriving the minimum protection score for certain event sequences. That fact alone is not determinative of the use of the IROFS in meeting the performance requirements because the IROFS listed for each accident sequence provide protection against several different pathways that can develop from each initiating event. The inspectors also noted that several of the event sequences were of the type, "What if filler area fuel transport cart is modified…?" which

does not meet the definition of an accident sequence that must be evaluated as part of the ISA. The licensee is revising the safety basis for the fuel transports cart and the Shipping and Receiving worktables to take credit for controlling the moderation level within individual containers. The final revision of the safety basis for these areas will be tracked as part of the licensee's corrective actions to the violation.

7.0 Exit Meeting

The inspectors presented the inspection scope and results to members of the licensee's management and staff during an exit meeting on July 19, 2012. The licensee acknowledged and understood the findings as presented.

In addition, on July 30, the licensee provided a revised analysis of the Met Lab Fuel Storage Cabinets (NCS-2012-118) to the NRC.

SUPPLEMENTARY INFORMATION

1.0 List of Items Opened, Closed, and Discussed

Items Opened

IFI 70-27/2012-204-01	Tracks the licensee's long-term corrective actions and potential design changes to the RTR Arc Melt Vacuum Pump System.
VIO 70-27/2012-204-02	Failure to analyze the new configuration and update the documentation during the change review for the larger bread pans.
URI 70-27/2012-204-03	Tracks the implementation of the "permitted as necessary" administrative control on interspersed moderation without the establishment of specific limits and the adequacy of the control given modeling assumptions.
VIO 70-27/2012-204-04	Failure to implement and maintain an IROFS (doubly-encased pipes) identified in the ISA Summary for the Pharmacy and Shipping and Receiving areas.

Items Closed

URI 70-27/2012-202-04	Tracks the licensee's review of the safety basis and extent of condition for doubly-encased piping in moderation controlled areas.

2.0 Event Notices Reviewed

EN 48091	**Retracted**	Bread pans exceeded the volume limit of 2.5 liters.

3.0 Inspection Procedures Used

IP 88015	Nuclear Criticality Safety Program
IP 88016	Nuclear Criticality Safety Evaluations and Analyses
IP 88017	Criticality Alarm Systems

4.0 Partial List of Contacts

B&WNOG

A. England	Manager, Licensing and Safety Analysis
D. Faidley	Manager, Nuclear Criticality Safety
J. Manning	Manager, Quality Control
B. Morcom	Manager, Assembly Operations
S. Nagley	Manager, Uranium Processing Operations
B. O'Donnell	Engineer, Nuclear Criticality Safety
D. Ward	Manager, EHS&S
L. Wetzel	Senior Engineer, Nuclear Criticality Safety
C. Yates	Manager, Nuclear Safety & Licensing

NRC

T. Hiltz	Branch Chief, Technical Support Branch, NRC Headquarters
S. Subosits	Senior Resident Inspector, NRC Region II
T. Sippel	Criticality Safety Inspector, NRC Headquarters
C. Tripp	Senior Criticality Safety Inspector, NRC Headquarters

5.0 List of Acronyms and Abbreviations

10 CFR	Title 10 of the *Code of Federal Regulations*
^{235}U	Uranium-235
B&WNOG/Licensee	Babcock and Wilcox Nuclear Operations Group, Inc.
CA	Corrective Action
CAP	Corrective Action Program
CIDAS	Criticality incident Detection Alarm System
CR	Change Request
EN	Event Notice
IFI	inspector follow-up item
IP	inspection procedure
IROFS	item relied on for safety
ISA	integrated safety analysis
L	Liter
LCO	Limiting Condition of Operation
NCS	nuclear criticality safety
NCSE	nuclear criticality safety evaluation
QWI	Quality Work Instruction
ROL	Routing Operating Limit
SAR	Safety Analysis Report
SER	Safety Evaluation Report or Safety Evaluation Request
URI	Un-resolved Item
VIO	Violation