EA-24-039

Pre-decisional Enforcement Conference

NRC Region II
Atlanta, Georgia

August 28, 2024

24-043

BWXT Nuclear Operations Group, Inc. Attendees and Agenda

Attendees:

- Jim Bittner, Vice President and General Manager, NOG-L
- Rich Freudenberger, Environment, Safety, Health & Safeguards Manager, NOG-L
- Daniel Ashworth, Licensing & Safety Analysis Manager, NOG-L
- William Gerding, Nuclear Criticality Safety Engineer, NOG-L

Agenda:

- Opening Remarks
- System Overview
- Identification
- Investigation
- Corrective Actions
- Enforcement Perspective and Safety Significance
- Closing Remarks

Overview

- On October 17, 2023, BWXT Nuclear Operations Group, Inc. – Lynchburg (SNM 42) made a report to the NRC, under 10 CFR 70.50(b)(2), identifying a design issue with the Criticality Accident Alarm System (CAAS) that resulted in the inability to ensure detection of a postulated criticality accident, specified in 10 CFR 70.24.

- NRC Violation: Failure to meet 10 CFR 70.24 (a)(1) due to the failure to ensure criticality accident alarm detectors could detect the minimum accident of concern. (07000027/2024006-01)

Criticality Accident Alarm System (CAAS) Overview

- Engineering Design began in 2011, commissioned in 2012.
  - Provides coverage for ~1.2 million $ft.^2$ of production space and consisted of 183 Detectors, 2 Panels.
- NOG-L uses a gamma sensitive system that alarms in a 100 mRem/hr field within 1 second (factory set).
  - Manufactured by Pajarito (Alpha Safety).
  - Three (3) loops of detection – 2 out of 3 logic for activation.
  - Analysis utilized a minimum accident of concern (MAOC) with fission yield of ~10^{14}.
    - MAOC – NOG-L's term for a criticality as defined in 10 CFR 70.24(a)(1).
  - Detector placement analysis used a calculation setpoint of 150 mRem/hr.
  - Calculated dose rate less 2x uncertainty is compared to the setpoint.

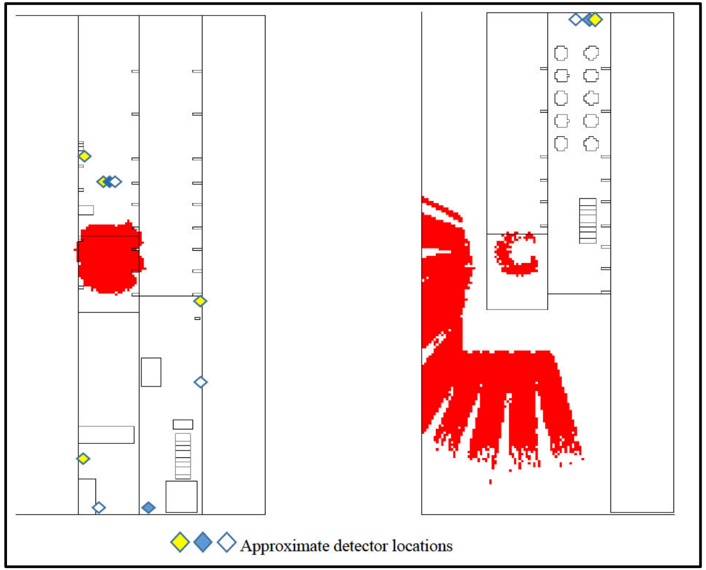
CAAS Detector

Identification of the Design Issue

- A Process Analysis (PA) was being developed for processing Research Test Reactor (RTR) uranium-molybdenum elements in the RTR autoclave.
  - The PA methodology contains a section on CAAS coverage and requires the evaluator to judge whether existing coverage is adequate.
- The engineer reviewed the CAAS design, NCS-TR-00004, for the area.
  - NCS-TR-00004 illustrated CAAS coverage for Bay 5A (autoclave).
- The engineer presented a questioning attitude and challenged the assumptions of the design & analysis when he noticed the source term was above the autoclave (vessel) and not located inside it.
- The engineer and team were positively recognized for identifying the issue.

Evaluation of the Design Issue

- During October, calculations were performed that consisted of placing the source term inside the autoclave vessel and included actions to refine the model's accuracy.
- Conclusion: MAOC inside the autoclaves would not be detected by the CAAS.
- Condition reported to NRC on October 17, 2023.
- NCS-TR-00004 was reviewed for all processes similar to autoclave/anneal – vertical vessels below grade level and/or large tanks containing water that could act as shielding.



First Floor - Autoclave Area Basement

Autoclave 3 Source Term - MAOC
Preliminary Results (October 2023)

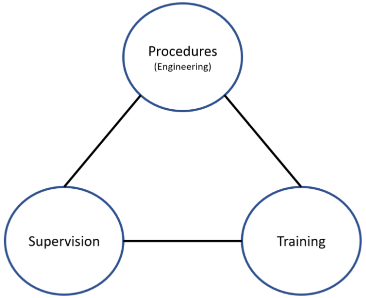
150 mRem/hr dose rates from the source term in Autoclave 3.
Left is at First Floor Detector Level
Right is at Basement Detector Level

Extent of the Design Issue

- The source term was in a similar configuration in the following liquid processes:
  - UT Clean, Final Clean, Pickle, Autoclave/Annealing, and Water Volume.
- Processing of components and material in the areas was suspended until compensatory measures could be implemented to achieve compliance.
  - Electronic dosimeters, set to alarm at 15 mRem/hr with dedicated monitoring personnel, were established in the above areas.
  - Waste treatment tank areas were added to the potentially affected areas/processes due potential shielding.
- Elements of a healthy nuclear safety culture:
  - Looking for weaknesses,
  - Questioning attitude,
  - Challenging assumptions, and
  - Immediate actions to restore compliance.
- Details associated with the assumptions regarding the MAOC were unlikely to be identified by normal surveillances or routinely scheduled QA activities.

Investigation & Reviews

- Level 1 Corrective Action initiated.
- The investigation team comprised of members of:
  - Nuclear Criticality Safety,
  - Licensing & Safety Analysis,
  - Safety Culture & Regulatory Training, and
  - Quality Engineering (Lead).
- Formal Investigation Tools were utilized:
  - Nuclear Work Model Critique,
  - 5 Whys Analysis – Root Cause,
  - Safety Culture Implication Review.



Nuclear Work Model

- *Why did the situation happen?*
- *Why was the situation overlooked?*
- *Why did the possibility exist for the situation to occur?*

Root Causes

- *Human Error:* The original NCS Engineer, performing the design & analysis in 2011-2012, misinterpreted the requirements leading to an inadequate selection of input parameters to the CAAS program.
  - Placing the source term (MAOC) 2 meters above the "reacting" vessel *vs.* Placing the source term within the vessel.
- *Complexity/Timing:* Having a single calculation preparer and a single calculation reviewer, while performing First-Of-A-Kind (FOAK), large, and complex analysis resulted in a human error situation.
- *Communication/FOAK:* The lack of communication and periodic oversight before, during, and after the implementation of the CAAS system reduced the opportunity to prevent/detect the application of incorrect input parameters.
  - Principal NCS Engineer primarily working alone.
  - Minimal use of team reviews for design inputs.
  - Qualified peer reviewer and supervisor reviews did not identify error.

Corrective Actions - Plant

- Compensatory Measures:
  - Personal Electronic Dosimeters (PEDs) implemented in the eight (8) areas.
  - Employee and management training was performed on required actions.
  - Formal Conduct of Operations review and formal restart authorization of the affected areas.
- Capital Improvement Project:
  - ~$2.8 million allocated for modeling effort and CAAS upgrade.
  - Review assumptions and source term inputs for the areas.
    - Redefine applicable source term.
  - Perform necessary analysis for the areas.
    - Using an industry subject matter expert (SME) & internal resources.
  - Procure and install necessary detection equipment.

Personal Electronic Dosimeter

Corrective Actions - Plant

Current State

Affected Areas	Re-Analysis Complete	Additional Detection Rq'd.	Facility Mods Complete	Compensatory Measures In Place
Autoclave	Yes	No	Yes	No
Anneal	Yes	Yes	Yes	No
Final Clean	Yes	Yes	Yes	No
Pickle	Yes	Yes	Yes	No
UT Clean	Yes	Yes	Yes	No
Water Volume	No	-	No	Yes
LLR Retention	No	-	No	Yes
LLR Equalization	No	-	No	Yes

- Project Completion Date – August 2025

Corrective Actions - Processes

- A procedure for project leadership guidelines was established for Complex FOAK NCS Analyses (NCSE-04).
  - Assess the technical background and experience of the Engineer(s) and Peer Reviewer(s) relative to the skills required for the specific project/analysis. *(Human Error, Complexity/Timing)*
  - Benchmarking with other organizations or industry SME's. *(Human Error, Complexity/Timing, Communication/FOAK)*
  - Periodic team meetings that foster skeptical thinking to discuss the design, project, and/or analysis and challenge the base assumptions. *(Communication/FOAK)*
  - Currently being utilized for CAAS upgrade project at the Lynchburg Technology Center (LTC).
  - Will be utilized for upcoming projects that will require FOAK analysis, due to processes, equipment, and/or technologies (e.g., DRACO, U-Mo Casting, etc.).

Corrective Actions - Processes

- Review inputs of the original CAAS analysis completed in 2012 to validate that these inputs meet the requirements of SNM-42, Chapter 5, Section 5.6.
  - This review is ongoing, in parallel to the reanalysis of the identified areas.
  - Improvements have been identified pertaining to source term development.
  - Completion Target: December 31, 2025.
- Review SNM-42, Chapter 5 for requirements with infrequent NCS Engineering involvement or analysis that have the potential for inadequate interpretation and assess the adequacy of the associate NCS analysis.
  - Currently reviewing NCS Validation.
  - Completion Target: December 31, 2025.
- Continue the Process Analysis Project.
  - Lessons Learned from this event have been shared with the project team.

Corrective Actions - People

- Structured on the Job Training (SOJT) Qualifications & Training Requirements for Nuclear Criticality Safety Engineers.
  - Requires familiarity with the difference between CAAS analysis (dose rate) and Nuclear Criticality Safety Evaluations. *(Human Error)*
  - Incorporates lessons learned from this incident. *(Human Error)*
  - Required reading and understanding of the Guidelines for Complex FOAK NCS Analyses. *(Human Error, Complexity/Timing, Communication/FOAK)*
- Internal resources development commitment.
  - 2 employees have completed ORNL's SCALE Criticality Safety and Radiation Shielding Course. *(Human Error)*
  - Practical application has occurred under the guidance of an Industry SME. *(Human Error, Communication/FOAK)*

Enforcement Perspective

- The circumstances of this condition align with violations involving Old Design Issue(s) concerning engineering, design, and/or installation.
  - ✓ It was identified by BWXT as a result of a voluntary initiative.
    - PA process was initiated as a voluntary effort.
    - NRC commitment was made in 2018 in response to a previous enforcement matter .
  - ✓ It was or will be corrected, including immediate corrective action and long-term comprehensive corrective action to prevent recurrence, within a reasonable time.
    - Facility modifications to upgrade the Criticality Accident Alarm System.
    - Improvements to complex, FOAK Nuclear Criticality Safety project management processes.
    - Additions to Training and Qualification programs for NCS Engineers to share event lessons learned and sustain knowledge transfer.
  - ✓ It was unlikely to be identified by efforts such as normal surveillances or routinely scheduled QA activities.
    - Details associated with the assumptions regarding the MAOC were unlikely to be identified by normal surveillances or routinely scheduled QA activities.

Safety Significance

- The likelihood of a criticality accident occurring remained highly unlikely – The performance requirements of 10 CFR 70.61 were maintained and all IROFS were available and reliable.
- The condition affected a small portion (~1.7%) of the facility.
  - These areas are not normally occupied, with most requiring permission and issuance of a key to enter.
  - Inherent shielding for areas normally occupied.
- Detection in normally occupied areas expected to occur when compared to reported criticality accidents.
  - MAOC calculated fission yield is $\sim10^{14}$ fissions.
  - All 22 reported* criticality accidents had yields of $>10^{15}$ fissions.
  - Nearly all reported* criticality accidents had yields of 10^{17} fissions.
  - Sensitivity studies showed likely detection at $\sim10^{15}$ fissions.

* T.P. McLaughlin, S.P. Monahan, N.L. Pruvost, et.al., LA13638, “A Review of Criticality Accidents”, 2000.