13.0 ACCIDENT ANALYSIS

This chapter of the Northwest Medical Isotopes, LLC (NWMI or the applicant) construction permit safety evaluation report (SER) describes the U.S. Nuclear Regulatory Commission (NRC) staff (the staff) technical review and evaluation of the preliminary accident analysis of the NWMI production facility as presented in Chapter 13.0, "Accident Analysis," of the NWMI preliminary safety analysis report (PSAR), Revision 3, and NWMI's responses to requests for additional information (RAIs).

The accident analysis for the NWMI production facility shows that the health and safety of the public and workers are protected, potential radiological and non-radiological consequences have been considered in the event of malfunctions, and the facility is capable of accommodating disturbances in the functioning of structures, systems, and components (SSCs). Additionally, the accident analysis demonstrates that facility controls have been identified to ensure that identified credible accidents, as defined in Section 3.3, "Definitions of Likelihood and Likelihood Categorization," of the NWMI Integrated Safety Analysis (ISA) Summary, could not lead to unacceptable radiological and non-radiological consequences to workers and the public.

SER Chapter 13.0, "Accident Analysis," provides an evaluation of the preliminary accident analysis of the NWMI production facility presented in PSAR Chapter 13.0, wherein NWMI describes accident-initiating events and scenarios, determination of consequences and identification of safety related SSCs. The applicant has chosen to use an ISA methodology which was derived from Title 10 of the *Code of Federal Regulations* (10 CFR) Part 70, "Domestic Licensing of Special Nuclear Material," consistent with "Final Interim Staff Guidance (ISG) Augmenting NUREG-1537, Part 2, 'Guidelines for Preparing and Reviewing Applications for the Licensing of Non-Power Reactors: Standard Review Plan and Acceptance Criteria,' for Licensing Radioisotope Production Facilities and Aqueous Homogeneous Reactors" (Reference 11), (see Chapter 13.3.2 of this SER) to demonstrate compliance with 10 CFR Part 50, "Domestic Licensing of Production and Utilization Facilities," for the production facility. This chapter also outlines the applicant's ISA methodology and its application to the NWMI production facility to define items relied on for safety (IROFS). As explained in SER Section 1.1.1, "Scope of Review," the NWMI construction permit application generally refers to the building that will house all activities, SSCs related to medical isotope production as its radioisotope production facility (RPF). The RPF consists of the production facility and the target fabrication area as discussed below. In this SER, the staff refers to the SSCs within the RPF associated with the activities that NWMI states it will conduct under a license for a 10 CFR Part 50 production facility as "the NWMI production facility" or "the facility." In this SER, the staff refers to the SSCs within the RPF associated with the activities that NWMI states it will conduct under a separate 10 CFR Part 70 license as "the target fabrication area." The staff reviewed the entire NWMI construction permit application to understand the anticipated interface between and impact on the NWMI production facility from the target fabrication area. However, the staff's findings and conclusions in this SER are limited to whether the NWMI production facility satisfies the 10 CFR Part 50 requirements for the issuance of a construction permit.

13.1 Areas of Review

The staff reviewed NWMI PSAR Chapter 13.0 against applicable regulatory requirements using appropriate regulatory guidance and standards to assess the sufficiency of the accident analysis of the preliminary design for the purposes of issuance of a construction permit. As part of this review, the staff evaluated descriptions and discussions of NWMI's accident analysis, with attention to the ISA methodology, design and operating characteristics, unusual or unique design features, and principal safety considerations. The accident analysis of the preliminary design was evaluated to ensure the sufficiency of principal design criteria; design bases; and general information relative to materials of construction, arrangement of structures and components, and approximate dimensions, as needed, to provide reasonable assurance that the final design will conform to the design basis. In addition, the staff reviewed NWMI's identification and justification for the selection of those variables, conditions, or other items, which are determined to be probable subjects of technical specifications (TSs) for the production facility. SSCs were also evaluated to ensure that they would adequately provide for the prevention of accidents and the mitigation of the consequences of accidents.

Areas of review for this section included the application of the ISA process to perform accident analysis, accidents with radiological consequences, and accidents with hazardous chemicals. Within these areas of review, the staff assessed processes conducted within the production facility; accident initiating events; loss of confinement; external events; critical equipment malfunction; inadvertent nuclear criticalities; facility fires; and chemical accident descriptions, mitigated and unmitigated consequences, and IROFS. The staff also reviewed the aforementioned areas in relation to the ISA Summary.

13.2 Summary of Application

NWMI states in PSAR Chapter 13 that its facility accident analysis, performed using the ISA methodology process as described in 10 CFR Part 70, provides the bases for establishing safety limits and designating IROFS for facility operations. A technical basis for control of those limits is provided in the PSAR and in supporting information for the ISA. Some portion of this technical basis is expected to be included in TSs. The accidents analyzed in this chapter also support the establishment of the design basis limits for the SSCs in the NWMI production facility processes. The facility design has design features and analysis assumptions that are important for understanding the bases of the accident analysis as it applies to the design of the facility. NWMI identified, through a systematic process, a variety of event types that are expected to be prevented or mitigated to acceptable limits for the credible accidents related to the production facility. NWMI states that production facility accident scenarios and analyses for the construction permit are based on the preliminary design of the facility and are considered preliminary from an operating licensing and final design standpoint.

NWMI PSAR Section 1.2.2, "Consequences from the Operation and Use of the Facility," states that there are potential exposures to the public from postulated accidents and that dose to workers and the public from postulated accidents are within the limits of 10 CFR 20.1201, Occupational dose limits for adults," and 10 CFR 20.1301, "Dose limits for individual members of the public."

NWMI PSAR Chapter 13.0 describes accident analysis methodology, accidents with radiological consequences, and accidents with hazardous chemicals for the NWMI production facility. The PSAR provides details on processes conducted within the facility; accident initiating events; loss of confinement; external events; critical equipment malfunction; inadvertent nuclear criticalities; facility fires; and chemical accident descriptions, consequences, IROFS, and surveillance requirements. The NWMI production facility design basis is supported by information provided in NWMI PSAR Chapter 13.0 through discussions related to the use of an ISA methodology which includes a process to determine anticipated events, assess the associated risk, and designate the IROFS needed to achieve acceptable risk levels. As stated in the PSAR, the accident analysis performed by NWMI considers the radiological consequences, chemical consequences, fire analysis, and criticality status of accidents defined as credible in the NWMI production facility.

NWMI PSAR Chapter 13.0 documents the basis for the identification and evaluation of accident scenarios in the NWMI production facility as follows:

- Implementation of an ISA methodology which includes a preliminary hazard analyses (PHA) performed using guidance from ISG Augmenting NUREG-1537, Part 1.

- The list of accident initiating events identified in the ISG Augmenting NUREG-1537, Part 1, Section 13b.1.2, “Accident Initiating Events.”

- Experience of the hazard analysis team.

- Preliminary design and design basis evaluations in the PSAR for the processes in the NWMI production facility.

- The determination of IROFS needed to prevent or mitigate credible accidents.

NWMI PSAR Section 13.1, “Accident Analysis Methodology and Preliminary Hazards Analysis,” Table 13-9, “Adverse Event Summary for Target Fabrication and Identification of Accident Sequences Needing Further Evaluation”; Table 13-10, “Adverse Event Summary for Target Dissolution and Identification of Accident Sequences Needing Further Evaluation”; Table 13-11, “Adverse Event Summary for Molybdenum Recovery and Identification of Accident Sequences Needing Further Evaluation”; Table 13-12, “Adverse Event Summary for Uranium Recovery and Identification of Accident Sequences Needing Further Evaluation”; Table 13-13, “Adverse Event Summary for Waste Handling and Identification of Accident Sequences Needing Further Evaluation”; Table 13-14, “Adverse Event Summary for Target Receipt and Identification of Accident Sequences Needing Further Evaluation”; Table 13-15, “Adverse Event Summary for Ventilation System and Identification of Accident Sequences Needing Further Evaluation”; and Table 13-16, “Adverse Event Summary for Node 8.0 and Identification of Accident Sequences Needing Further Evaluation,” discuss initiating events that could release fission products from irradiated targets while in process, in storage, or being transferred within the facility.

NWMI PSAR Sections 13.2.2, “Liquid Spills and Sprays with Radiological and Criticality Safety Consequences,” and 13.2.4, “Leaks into Auxiliary Services or Systems with Radiological and Criticality Safety Consequences,” discuss the potential for a criticality incident with either low-dose uranium solutions or high-dose uranium solutions. NWMI PSAR Section 13.2.2.9 states “The controls selected and described above will prevent a criticality associated with accidental spills and sprays of SNM [special nuclear material].” An accidental criticality is shown to be highly unlikely, as the facility has been designed with passive engineering design features and other safety-related (SR) controls to prevent criticality and assure that processes remain subcritical. Additionally, administrative controls and SR SSCs provide control on enrichments and target solution uranium concentration to further prevent inadvertent criticality. NWMI PSAR Sections 13.2.2 and 13.2.4 identify areas within the facility where an inadvertent criticality is possible and discuss controls that are used to reduce the likelihood of an inadvertent criticality. Additional criticality safety analysis discussion and the staff’s review can be found in Chapter 6.0 of this SER.

13.3 Regulatory Basis and Acceptance Criteria

The staff reviewed NWMI PSAR Chapter 13.0 against applicable regulatory requirements, using appropriate regulatory guidance and standards, to assess the sufficiency of the preliminary accident analysis for the issuance of a construction permit under 10 CFR Part 50. In accordance with paragraph (a) of 10 CFR 50.35, "Issuance of construction permits," a construction permit authorizing NWMI to proceed with construction of a production facility may be issued once the following findings have been made:

(1) NWMI has described the proposed design of the facility, including, but not limited to, the principal architectural and engineering criteria for the design, and has identified the major features or components incorporated therein for the protection of the health and safety of the public.

(2) Such further technical or design information as may be required to complete the safety analysis, and which can reasonably be left for later consideration, will be provided in the final safety analysis report (FSAR).

(3) Safety features or components, if any, which require research and development have been described by NWMI and a research and development program reasonably designed to resolve any safety questions associated with such features or components.

(4) On the basis of the foregoing, there is reasonable assurance that: (i) such safety questions will be satisfactorily resolved at or before the latest date stated in the application for completion of construction of the proposed facility, and (ii) taking into consideration the site criteria contained in 10 CFR Part 100, "Reactor Site Criteria," the proposed facility can be constructed and operated at the proposed location without undue risk to the health and safety of the public.

With respect to the last of these findings, the staff notes that the requirements of 10 CFR Part 100 are specific to nuclear power reactors and testing facilities, and therefore not applicable to the NWMI production facility. However, the staff evaluated the NWMI facility's site-specific conditions using site criteria similar to 10 CFR Part 100, by using the guidance in NUREG-1537, Part 1, "Guidelines for Preparing and Reviewing Applications for the Licensing of Non-Power Reactors, Format and Content," issued February 1996 (Reference 8) and Part 2, "Guidelines for Preparing and Reviewing Applications for the Licensing of Non-Power Reactors, Standard Review Plan and Acceptance Criteria," issued February 1996 (Reference 9). The staff's review in Chapter 2.0 of this SER evaluated the geography and demography of the site; nearby industrial, transportation, and military facilities; site meteorology; site hydrology; and site geology, seismology, and geotechnical engineering to ensure that issuance of the construction permit will not be inimical to public health and safety.

13.3.1 Applicable Regulatory Requirements

The applicable regulatory requirements for the evaluation of NWMI's preliminary accident analysis are as follows:

- 10 CFR 50.34, "Contents of applications; technical information," paragraph (a), "Preliminary safety analysis report."

- 10 CFR 50.40, "Common standards."
- 10 CFR 20.1201, "Occupational dose limits for adults."
- 10 CFR 20.1301, "Dose limits for individual members of the public."

13.3.2 Regulatory Guidance and Acceptance Criteria

The staff used its engineering judgment to determine the extent that established guidance and acceptance criteria were relevant to the review of NWMI's construction permit application, as much of this guidance was originally developed for completed designs of nuclear reactors. For example, in order to determine the acceptance criteria necessary for demonstrating compliance with 10 CFR regulatory requirements, the staff used:

- NUREG-1537, Part 1, "Guidelines for Preparing and Reviewing Applications for the Licensing of Non-Power Reactors, Format and Content," issued February 1996 (Reference 8).
- NUREG-1537, Part 2, "Guidelines for Preparing and Reviewing Applications for the Licensing of Non-Power Reactors, Standard Review Plan and Acceptance Criteria," issued February 1996 (Reference 9).
- "Final Interim Staff Guidance Augmenting NUREG-1537, Part 1, 'Guidelines for Preparing and Reviewing Applications for the Licensing of Non-Power Reactors: Format and Content,' for Licensing Radioisotope Production Facilities and Aqueous Homogeneous Reactors," dated October 17, 2012 (Reference 10).
- "Final Interim Staff Guidance Augmenting NUREG-1537, Part 2, 'Guidelines for Preparing and Reviewing Applications for the Licensing of Non-Power Reactors: Standard Review Plan and Acceptance Criteria,' for Licensing Radioisotope Production Facilities and Aqueous Homogeneous Reactors," dated October 17, 2012 (Reference 11).
- "Standard Review Plan for the Review of a License Application for a Fuel Cycle Facility," NUREG-1520, Revision 1, May 2010 (Reference 24).

The ISG Augmenting NUREG-1537 updated and expanded the guidance, originally developed for non-power reactors, to address medical isotope production facilities. For example, whenever the word "reactor" appears in NUREG-1537, it can be understood to mean "radioisotope production facility" as applicable. In addition, the ISG, at page vi, states that use of Integrated Safety Analysis methodologies as described in 10 CFR Part 70 and NUREG-1520, application of the radiological and chemical consequence likelihood criteria contained in the performance requirements of 10 CFR 70.61 "Performance requirements," designation of IROFS, and establishment of management measures are acceptable ways of demonstrating adequate safety for a medical isotope production facility. The ISG also states that applicants may propose alternate accident analysis methodologies, alternate radiological and chemical consequence and likelihood criteria, alternate safety features and alternate methods of assuring the availability and reliability of safety features. The ISG notes that the use of the term "performance requirements" when referring to 10 CFR Part 70, Subpart H, does not mean that the performance requirements in Subpart H are required for a radioisotope production facility license, only that their use may be found acceptable. NWMI used this ISG to inform the design of its facility and prepare its PSAR. The staff's use of reactor-based guidance in its evaluation of the NWMI PSAR is consistent with the ISG Augmenting NUREG-1537.

As appropriate, additional guidance (e.g., NRC regulatory guides, Institute of Electrical and Electronics Engineers standards, American National Standards Institute/American Nuclear Society standards) has been used in the staff's review of NWMI's PSAR. The use of additional guidance is based on the technical judgment of the reviewer, as well as references in NUREG-1537, Parts 1 and 2; the ISG Augmenting NUREG-1537, Parts 1 and 2; and the NWMI PSAR. Additional guidance documents used to evaluate NWMI's PSAR are provided as references in Appendix B, "References," of this SER.

13.4 Review Procedures, Technical Evaluation, and Evaluation Findings

The staff evaluated the technical information presented in NWMI PSAR Chapter 13.0, Revision 3 (Reference 60), as supplemented with NWMI's responses to RAIs to assess the sufficiency of the preliminary design and performance of NWMI's accident analysis for the issuance of a construction permit, in accordance with 10 CFR Part 50. The sufficiency of the NWMI preliminary accident analysis is determined by ensuring that the design and performance meets applicable regulatory requirements, guidance, and acceptance criteria, as discussed in Section 13.3, "Regulatory Basis and Acceptance Criteria," of this SER. The results of this technical evaluation are summarized in SER Section 13.5, "Summary and Conclusions." The technical review focused on the NWMI production facility. The target fabrication process was examined to determine whether operations in this area could introduce radiological and chemical hazards that significantly increased the accident consequences for the NWMI production facility licensed under the regulations of 10 CFR Part 50.

For the purposes of issuing a construction permit, the preliminary accident analysis may be adequately described at a conceptual level. The staff's evaluation of the preliminary accident analysis does not constitute approval of the safety of any design feature or specification. Such approval, if granted, would occur after an evaluation of the final design of the NWMI production facility, as described in the FSAR submitted as part of NWMI's operating license (OL) application.

For SER Sections 13.4.1 through 13.4.10, the staff evaluated the sufficiency of the preliminary identification, analysis, and determination of consequences of accident-initiating events and scenarios, as described in NWMI PSAR Sections 13.1 and 13.2, "Analysis of Accidents with Radiological and Criticality Safety Consequences," in part, by reviewing the processes conducted inside the production facility, accident initiating events, loss of confinement, external events, loss of normal electric power, mishandling or malfunction of equipment, inadvertent nuclear criticality in the production facility, and fires, using the guidance and acceptance criteria from Section 13b.1, "Radioisotope Production Facility Accident Analysis Methodology," of the ISG Augmenting NUREG-1537, Parts 1 and 2.

For SER Sections 13.4.1 through 13.4.10, consistent with the review procedures of the ISG Augmenting NUREG-1537, Part 2, Section 13b.1, the staff reviewed NWMI's accident methodology and analysis. The staff evaluated credible accidents identified in the ISA Summary; instruments, controls and automatic protective systems assumed to be operating normally before an initiating event; the identification of single malfunctions; the discussion of sequence of events and components and systems damaged during the accident scenario; mathematical models and analytical methods employed; radiation source term; and that potential radiation consequences to workers and public were presented and compared with acceptable limits.

13.4.1 Accident Analysis Methodology and Preliminary Hazards Analysis

The applicant evaluated the processes that occur within the NWMI facility through the performance of an ISA. The applicant documented the results of the evaluation in NWMI PSAR Chapter 13.0 and in an ISA Summary. NWMI PSAR Section 13.1.1 describes the different types of accident analysis methodologies as they are applied to the NWMI ISA. More specifically, NWMI defined accident likelihood categories, consequence severity categories, and a risk matrix that combined various likelihood and consequence categories to determine acceptable and unacceptable scenarios. These categories and the risk matrix are consistent with the guidance in NUREG-1520. In addition, NWMI described several accident analysis methodologies to include accident consequence analysis, what-if and structured what-if analyses, hazards and operability (HAZOP) study method event and fault tree analyses, and failure modes and effects analyses.

NWMI PSAR Section 13.1.3, “Preliminary Hazards Analysis Results,” describes the preliminary hazards analysis results based on the methodologies and hazard criteria from Section 13.1.1, “Methodologies Applied to the Radioisotope Production Facility Integrated Safety Analysis Process.” Specifically, the NWMI production facility accident sequence evaluation used what-if, structured what-if, and HAZOP methods to analyze each process node and identify certain accident sequences that require additional assessment via the quantitative risk analysis (QRA) process. The remaining steps of the process include determining IROFS and boundary definition packages based on the results of the QRA, establishing management measures, and incorporating the IROFS into the design and facility documentation.

The staff evaluated the steps of the ISA process and the following specific analyses of radiological and criticality accidents to assess the applicant’s implementation of its ISA methodology:

- Spills and spray accidents
- Dissolver offgas accidents
- Leaks into the auxiliary systems accidents
- Loss of electrical power
- Natural phenomena accidents
- Other accidents analyses

The staff reviewed the qualification of the ISA team members and notes that one member has experience in ISA, PHA, and industrial safety experience and that one member has experience in fire protection. At least one member has expertise in nuclear criticality safety (NCS) and radiological safety. The staff further notes that, given the number and anticipated functionality of administrative controls, the current ISA team does not include expertise in human reliability. To be consistent with the guidance in the ISG Augmenting NUREG 1537, Part 2, Section 13b.1, and for the purposes of the construction permit, expertise in human reliability is not required on the ISA team; however, for the FSAR the staff will further evaluate the technical bases for the failure frequencies or probabilities of administrative controls.

The staff finds that Chapter 13.0 of the NWMI PSAR and the ISA Summary are consistent with the ISG Augmenting NUREG 1537, Part 2, Section 13b.1 guidance in that the applicant’s ISA methodology reviews the systems and operating characteristics of the NWMI production facility that could affect safe operation or shutdown. Furthermore, NWMI PSAR Chapter 13.0 and the ISA Summary demonstrate that the applicant applied its ISA methodology to identify limiting accidents, analyze the evolution of the scenarios, and evaluate the consequences. The staff will confirm additional analyses and the details of the ISA process and specific technical topics, such as ISA team qualification, the designation of credible accident sequences, administrative controls, and supporting management measures, during its evaluation of NWMI's FSAR which will be based on NWMI's final design.

Based on its review, the staff finds that the level of detail provided on ISA processes demonstrates an adequate basis for a preliminary design and satisfies the applicable acceptance criteria of the ISG Augmenting NUREG-1537, Part 2, Section 13b.1, allowing the staff to make the following findings:

(1) The applicant's use of ISA methodologies as described in 10 CFR Part 70 and the ISG Augmenting NUREG-1537, application of the radiological and chemical consequence and likelihood criteria contained in the performance requirements of 10 CFR 70.61, and identification of management measures provide reasonable assurance that the applicant's ISA process contains the elements that support the adequate identification of capabilities and features to prevent or mitigate potential accidents and protect the health and safety of the public and workers.

(2) The definitions of accident likelihood categories (i.e., highly unlikely, unlikely and credible), consequence severity categories, and the risk matrix are consistent with the guidance in NUREG-1520 and are acceptable for use in the ISA analysis.

(3) The various methodologies that NWMI described (e.g., HAZOP, fault tree analysis) are accepted approaches in accident analysis and ISA development.

(4) The performance of a preliminary hazards analysis, which include accident sequence evaluations, is sufficient to identify accident sequences that require additional quantitative evaluation.

(5) The preliminary ISA performed by the applicant provides the basis to establish that the design of the production facility including the associated SSCs can adequately assure that acceptable risk to the workers and public can be established and maintained.

(6) Evaluations performed by the applicant provide reasonable assurance that all production facility nuclear processes will be subcritical during normal and credible abnormal operating conditions and that high consequence accidents will be controlled to be highly unlikely, and that intermediate consequence accidents will be controlled to be unlikely.

Therefore, the staff concludes that NWMI's preliminary accident analysis methodology, as described in NWMI PSAR Section 13.1.1, is sufficient and meets the applicable regulatory requirements and guidance for the issuance of a construction permit in accordance with 10 CFR Part 50. Further technical or design information required to complete the safety analysis may reasonably be left for later consideration. The staff will evaluate the results of the NWMI analysis of accident initiating events as part of the review of the final design in the FSAR, which will be submitted as part of the OL application.

13.4.2 Accident Initiating Events

NWMI PSAR Section 13.1.2, "Accident-Initiating Events," describes several accident initiating events that are included in the PHA. Specifically, NWMI identified criticality accidents, losses of electric power, external events, critical equipment malfunctions, operator errors, fires and explosions, and other events potentially related to unique production facility operations. In addition, NWMI developed top-level accident sequence categories in order to compare them to the accident initiating events described in NUREG-1537, Part 1, and to demonstrate that the PHA considers a full range of accident initiating events. The PHA is also broken down into eight primary nodes, each with associated sub-processes, which are cross referenced against the top-level accident sequence categories. The applicant described the other aspects of the safety program similar to that discussed in 10 CFR 70.62, "Safety program and integrated safety analysis" (referenced in the ISG Augmenting NUREG-1537, Part 2, as an acceptable way to demonstrate compliance with 10 CFR Part 50 for radioisotope production facilities). The staff evaluated process information as described in Chapter 4.0 of the NWMI PSAR, "Radioisotope Production Facility Description," and management measures in Chapter 12.0 of the PSAR, "Conduct of Operations."

Based on its review, the staff finds that the level of detail provided demonstrates an adequate design basis for a preliminary design and is consistent with ISG Augmenting NUREG-1537, Part 2, Section 13b.1 allowing the staff to make the following findings:

(1) The applicant implemented an adequate accident analysis for the safety program based on the preliminary design consistent with 10 CFR 70.62 and adequately described the nature of the management measures that will be developed in Chapter 12.0 of the NWMI PSAR, and process information as described in Chapter 4.0 of the NWMI PSAR. Analysis of the specific management measures may reasonably be left for later consideration and will be provided in the FSAR.

(2) There is reasonable assurance that NWMI has addressed significant credible accidents involving internal production facility processes, abnormal events, and process deviations and credible external events that could result in serious adverse consequences to workers and the public based on the preliminary design.

(3) The applicant identified designated engineered and administrative safety features in the production facility that are necessary to provide preventive or mitigative measures based on the preliminary design, that give reasonable assurance that the facility will operate in compliance with the performance requirements proposed by the applicant.

(4) The results of the accident analysis demonstrate, based on the preliminary design, adequate safety of the NWMI production facility by meeting the performance requirements proposed by the applicant for demonstrating acceptable risk.

(5) Credible accidents at the NWMI production facility were considered and evaluated at the preliminary design stage. The demonstrations of the risk associated with credible accidents were shown to be adequate to prevent or mitigate the release of radioactive materials, in amounts exceeding regulatory limits, to uncontrolled areas as a result of credible accidents.

(6) The applicant considered the consequences to the public and the workers for the credible chemical accidents at the NWMI production facility that reach the intermediate

or high consequence thresholds as defined by the applicant consistent with the guidance in the ISG Augmenting NUREG-1537.

Therefore, the staff concludes that NWMI's analysis of accident initiating events based on the preliminary design, as described in NWMI PSAR Section 13.1.2, is sufficient and meets the applicable regulatory requirements and guidance for the issuance of a construction permit in accordance with 10 CFR Part 50, based on the accident analysis methodologies and the PHA results described in the NWMI PSAR, Sections 13.1.1 and 13.1.3, respectively. The staff will evaluate whether NWMI has identified all credible accidents and the results of NWMI's analysis of accident initiating events as part of the review of the final design in the FSAR which will be submitted as part of the OL application.

13.4.3 Liquid Spills and Sprays with Radiological and Criticality Safety Consequences

NWMI PSAR Section 13.2.2 presents the evaluation of liquid solution spill or spray events resulting in a radiological exposure hazard to workers and the public. Spill or spray events also consider fissile solutions that may result in an inadvertent criticality. Multiple vessels and piping systems throughout the NWMI production facility contain process liquids of varying radiological and/or fissionable compositions. The PHA reduced the variety of possible spill and spray events to the configurations below that bound the range of potential initial conditions:

- High-dose uranium solutions typical of irradiated target dissolution processes.
- Molybdenum (Mo) product solution typical of the Mo purification processes.

Two high-dose uranium solutions are evaluated and documented in the construction permit application:

- Dissolver product in the production facility's irradiated target dissolution system.
- Uranium separation feed in the uranium recovery and recycle system.

The postulated accident initiating event is a process equipment failure, an operator error, or a fire/explosion. The accident scenario would progress with a spray or leak resulting in rapid draining of a solution tank.

Unmitigated spill and spray-type releases have the potential to produce direct exposure and confinement releases with high consequence to workers and the public. Hot cell shielding is designed to provide protection from uncontrolled liquid spills and sprays that result in redistribution of high-dose uranium and Mo-99 product solution in the hot cell. From a direct exposure perspective, a liquid spill does not represent a failure or adverse challenge to the hot cell shielding boundary function. However, the hot cell shielding boundary must also function to prevent migration of liquid spills to uncontrolled areas outside the shielding boundary.

Liquid spill and spray-type releases occur as a result of the partial failure of process vessels to contain either the fissile solution (for areas outside of the hot cell) or to contain fissile or high-dose radiological solutions (for areas inside the hot cell). In either case, the process vessel spray release results in an event that carries with it a higher airborne radionuclide release magnitude than a simple liquid spill. The spray-type release also carries the extra hazard of potential chemical burns to eyes and skin, with the complication of radiological contamination. Consequently, spray protection is a secondary safety function needed to satisfy performance criteria. The liquid spill and spray confinement safety function of the hot cell liquid confinement boundary IROFS is then credited for confining the spray to the hot cell and protecting the worker from sprays of radioactive, caustic, or acidic solution with the potential to cause intermediate or high consequences. The airborne filtering safety feature of the hot cell secondary confinement boundary IROFS is credited with reducing airborne concentrations in the hot cells to levels outside the hot cell boundary, which are below intermediate consequence levels for workers and the public during the event.

The NWMI calculated dose consequences, which are documented in NWMI PSAR Section 13.2.2.7.1, "Direct Exposure Consequences," demonstrate that the irradiated target dissolver product release case is the bounding case with regard to radiological dose consequences. NWMI PSAR Section 13.2.2.7.2, "Confinement Release Consequence," states that the bounding accident has been re-analyzed using the Radiological Safety Analysis Code computer code and revised dose consequence values were provided. The unmitigated total effective dose equivalent (TEDE) dose to the nearest permanent resident (432 meters (m) (1,417 feet (ft)) is 300 milli roentgen equivalent man (mrem). The maximum TEDE dose consequence to the public is 1.8 rem and occurs at a distance of 1,100 m (3,608 ft). The staff notes that this maximum dose consequence to the public correlates to a low consequence category unmitigated event. However, NWMI states that this unmitigated bounding accident scenario (spray release of dissolver product solution) is being considered as an intermediate consequence event with respect to offsite public dose consequence for the PSAR design process and will be evaluated further in the NWMI FSAR.

NWMI stated that the NWMI operating staff should not receive an occupational exposure from a spray leak or spill in the hot cells due to the shielded walls and ventilation flow rate. NWMI also stated that an additional accident scenario, a spill of Mo-99 product during container loading operations, will be re-evaluated in the NWMI OL application. Operating staff dose consequence estimates and worker stay time for this accident scenario will be provided in the NWMI FSAR submitted as part of the OL application. The staff is tracking this item in Appendix A, "Post Construction Permit Activities – Construction Permit Conditions and Final Safety Analysis Report Commitments," of this SER.

As NWMI has considered this accident to result in intermediate consequences to the offsite public, IROFS are being credited to mitigate the accident consequences. Three IROFS are identified to control radiological consequences from liquid spill and spray accidents from process vessels. The IROFS are the (a) RS-01, Hot Cell Liquid Confinement Boundary; (b) RS-03, Hot Cell Secondary Confinement Boundary; and (c) RS-04, Hot Cell Shielding Boundary.

NWMI credited the Zone I exhaust system filters (part of IROFS RS-03) to mitigate the consequences of the bounding liquid spray accident and estimated the resulting dose consequences to be 0.030 rem to the offsite public at the nearest residence and 0.18 rem to the maximally exposed off site public. The staff notes that this mitigated dose to the offsite public is reduced to the low consequence category.

Liquid spill and spray events involving solutions containing fissile material also have the potential for producing inadvertent nuclear criticalities that must be prevented. The following IROFS are identified to control nuclear criticality aspects for the production facility liquid spill and spray events: (a) Pencil Tank and Vessel Spacing Control Using Fixed Interaction Spacing of Individual Tanks or Vessels; (b) Floor and Sump Geometry Control on Slab Depth, Sump Diameter or Depth for Floor Spill Containment Berms; and (c) Double-Wall Piping.

In its response to RAI 13.1-1 (Reference 16), NMWI states that the FSAR will clearly state its intent to prevent the occurrence of a criticality accident, regardless of whether the event results in a high radiation dose. The evaluation of criticality safety can be found in Chapter 6.0, “Engineering Safety Features,” of the SER. The staff is tracking this item in Appendix A of this SER.

The staff reviewed the liquid spill and spray events discussion and the ISA accident sequence information in NWMI PSAR Tables 13-10, 13-11, and 13-12 and determined with reasonable assurance that the applicant has adequately identified credible accident sequences and potential radiological and chemical consequences at the NWMI production facility.

Based on its review, the staff finds that the level of detail provided on NWMI’s liquid spills and sprays with radiological and criticality safety consequences event demonstrates an adequate design basis for a preliminary design and satisfies the applicable acceptance criteria of the ISG Augmenting NUREG-1537, Part 2, Section 13b.1, allowing the staff to make the following findings:

- In combination with the NCS program reviewed in Chapter 6.0, of this SER, there is reasonable assurance that NWMI has described a NCS program that will, if properly implemented, ensure that all facility processes are subcritical under both normal and credible abnormal conditions, and will comply with the double contingency principle.

- The applicant adequately considered the consequences of liquid spills and sprays involving radioactive and fissile solutions within the NWMI production facility events based on the preliminary design. Radiation doses to the public for the bounding case were shown to be within acceptable limits (low consequence category).

Therefore, the staff concludes that NWMI’s preliminary analysis of the liquid spills and sprays events based on the preliminary design, as described in NWMI PSAR Section 13.2.2, is sufficient and meets the applicable regulatory requirements and guidance for the issuance of a construction permit in accordance with 10 CFR Part 50. Further technical or design information required to complete the safety analysis can reasonably be left for later consideration, and will be provided in the FSAR. The staff will confirm that the final design conforms to the design basis during its evaluation of NWMI’s FSAR.

13.4.4 Target Dissolver Off-gas Accidents with Radiological Consequences

NWMI PSAR Section 13.2.3, “Target Dissolver Offgas Accidents with Radiological Consequences,” presents the evaluation of target dissolver offgas accidents resulting in a radiological exposure hazard to workers and the public. This accident is the loss of efficiency of the iodine removal unit (IRU) due to a process upset or equipment failure during dissolution of irradiated targets. The accident initial condition is assumed to be the release of iodine generated from a single dissolution of four University of Missouri – Columbia Research Reactor (MURR) targets at 8 hours post irradiation. The accident scenario would progress with a process upset that assumes that all of the iodine from the dissolution evolves from the dissolver solution and remains in the offgas stream to the IRUs, resulting in a release of iodine to the environment with a duration of 2 hours. NWMI has determined that the unmitigated likelihood of this event is “not unlikely.”

Calculated dose consequences demonstrated that the target dissolution offgas release case results in an unmitigated offsite public TEDE dose of 6.65 rem at a distance of 1,100 m (3,608 ft). This is an intermediate consequence category unmitigated event.

NWMI PSAR Section 13.2.3.8, "Identification of Items Relied on for Safety and Associated Functions," identifies and describes the safety functions of the following two IROFS to mitigate the consequences of this postulated accident:

- IROFS RS-03, "Hot Cell Secondary Confinement Boundary"
- IROFS RS-09, "Primary Off-gas Relief System"

NWMI PSAR Section 13.2.3.9, "Mitigated Estimates," states that detailed information including worker dose estimates and frequency will be provided in the NWMI FSAR submitted as part of the OL application.

The staff reviewed the target dissolver offgas accident discussion and the ISA accident sequence information in NWMI PSAR Table 13-10, and finds that the applicant has adequately identified credible accident sequences and potential radiological and chemical consequences at the NWMI production facility.

Based on its review, the staff finds that the level of detail provided on NWMI's target dissolver offgas accident with radiological consequences event demonstrates an adequate design basis for a preliminary design and satisfies the applicable acceptance criteria of the ISG Augmenting NUREG-1537, Part 2, Section 13b.1, allowing the staff to make the following finding:

- The applicant adequately considered the consequences of a target dissolver offgas accident involving radioactive material within the facility events. Radiation doses to the public and staff will be within acceptable limits, and the safety and health of the staff and public will be adequately protected.

Therefore, the staff concludes that NWMI's analysis of the target dissolver offgas accident based on the preliminary design, as described in NWMI PSAR Section 13.2.3, is sufficient and meets the applicable regulatory requirements and guidance for the issuance of a construction permit in accordance with 10 CFR Part 50. Further technical or design information required to complete the safety analysis can reasonably be left for later consideration, and will be provided, in the FSAR. The staff will confirm that the final design conforms to the design basis during its evaluation of NWMI's FSAR.

13.4.5 Leaks into Auxiliary Services or Systems with Radiological and Criticality Safety Consequences

NWMI PSAR Section 13.2.4, "Leaks into Auxiliary Services or Systems with Radiological and Criticality Safety Consequences," presents the evaluation of leaks into auxiliary services or systems with a radiological exposure or inhalation hazard to workers and an inhalation hazard for the public. Leaks into auxiliary services or systems also consider fissile solutions that may result in an inadvertent criticality. Multiple vessels and piping systems throughout the NWMI production facility contain process liquids of varying compositions. The bounding source term was selected by NWMI to be the dissolvers or the feed tanks in the Mo recovery and purification system. Two radionuclide liquid process streams are identified for analysis:

- the dissolver product stream, decayed 8 hours, post irradiation
- the uranium separation feed stream, decayed 504 hours, post irradiation

In each case, a jacketed vessel is assumed to be filled with the appropriate process liquid solution, with the process offgas ventilation system operating. A level monitoring system will be available to monitor tank transfers and stagnant store volumes on all tanks processing low-enriched uranium or fission product solutions.

The accident initiating event is generally described as a process equipment failure. The event is associated with leaks of enriched uranium solution into heating and/or cooling coils surrounding safe-geometry tanks or vessels. The event assumes that the primary confinement fails, which allows radioactive or fissile solutions to enter an auxiliary system. Radioactive or fissile solution leaks across the mechanical boundary between a process vessel and associated heating/cooling jacket into the heating/cooling media. Where heating/cooling jackets or heat exchangers are used to heat or cool a fissile and/or high-dose process solution, the potential exists for the barrier between the two to fail and allow fissile and/or high-dose process solution to enter the auxiliary system. If the auxiliary system is not designed with a safe-geometry configuration, or if this system exits the hot cell containment, confinement, or shielding boundary in an uncontrolled manner, either an accidental criticality is possible or a high-dose to workers or the public can occur.

Where auxiliary services enter process solution tanks, the potential exists for backflow of high-dose radiological and/or fissile process solution into the auxiliary service systems (e.g., purge air, chemical addition line, water addition line, etc.). Since these systems are not designed for process solutions, this event can lead to either accidental nuclear criticality or to high-dose radioactive exposures to workers occupying areas outside the hot cell confinement boundary.

The hazards analyses made no assumption about the geometry or the extent of the heating/cooling subsystem. Consequently, an assumption by NWMI is made that without additional control, a credible accidental nuclear criticality could occur, as the fissile solution enters into the heating/cooling system not designed for fissile solution, or as the solution exits the shielded area and creates a high worker dose consequence. If the system is not a closed loop, a direct release to the atmosphere can also occur. Either of these potential outcomes can exceed the performance criteria of one process upset, leading to accidental nuclear criticality or a release that exceeds intermediate or high consequence levels for dose to workers or the public.

NWMI has determined that the unmitigated likelihood of these postulated events are “not unlikely.” NWMI PSAR Section 13.2.4.8, “Identification of Items Relied on for Safety and Associated Functions,” identifies and describes the safety functions of several IROFS and defense-in-depth features selected to reduce the event likelihood and to mitigate the consequences of this postulated accident. The IROFS identified for these events include: (a) RS-04, hot cell shielding boundary; (b) CS-06, pencil tank and vessel spacing control; (c) CS-10, closed safe geometry heating or cooling loop with monitoring and alarm; (d) CS-27, closed heating or cooling loop with monitoring and alarm; (e) CS-20, evaporator or concentrator condensate monitoring; (f) CS-18, backflow prevention device; and (e) CS-19, safe geometry day tanks.

In its response to RAI 13.1-1 (Reference 16), NMWI states that the FSAR it will clearly state its intent to prevent the occurrence of a criticality accident, regardless of whether the event results in a high radiation dose. The evaluation of criticality safety can be found in Chapter 6.0 of this SER. The staff is tracking this item in Appendix A of this SER.

The staff reviewed the leaks into auxiliary services or systems event discussion and the ISA accident sequence information in NWMI PSAR Tables 13-10 and 13-12, and finds that the applicant has adequately identified credible accident sequences and potential radiological and chemical consequences at the NWMI production facility.

Based on its review, the staff finds that the level of detail provided on NWMI's leaks into auxiliary services or systems with radiological and criticality safety consequences event demonstrates an adequate design basis for a preliminary design and satisfies the applicable acceptance criteria of the ISG Augmenting NUREG-1537, Part 2, Section 13b.1, allowing the staff to make the following findings:

(1) There is reasonable assurance that NWMI described an NCS program that will, if properly implemented, ensure that all facility processes are subcritical under both normal and credible abnormal conditions, and will comply with the double contingency principle.

(2) The applicant adequately considered the consequences of leaks into auxiliary services or systems involving radioactive and fissile solutions within the facility events. The consequences of the leaks into auxiliary services or systems events have been estimated and shown to be adequately mitigated or prevented by the selection of IROFS.

Therefore, the staff concludes that NWMI's analysis of the leaks into auxiliary services and systems events based on the preliminary design, as described in NWMI PSAR Section 13.2.4, is sufficient and meets the applicable regulatory requirements and guidance for the issuance of a construction permit in accordance with 10 CFR Part 50. Further technical or design information required to complete the safety analysis can reasonably be left for later consideration, and will be provided, in the FSAR based on the final design. The staff will confirm that the final design conforms to the design basis during its evaluation of NWMI's FSAR.

13.4.6 Loss of Power

NWMI PSAR Section 13.2.5, "Loss of Power," discusses the events that could result from the sudden loss of normal electrical power. NWMI PSAR Section 13.2.5.6, "Radiation Source Term," states, "Detailed information describing radiation source terms for the loss of power event will be developed for the Operating License Application." NWMI PSAR Section 13.2.5.7, "Evaluation of Potential Radiological Consequences," states, "A detailed evaluation of potential radiological consequences … will be provided in the Operating License Application." NWMI stated that loss of power was identified as an initiating event in numerous NWMI production facility accident scenarios. NWMI's conclusion was that no additional IROFS were identified from loss of power events. The staff notes that loss of power is considered in other ISAs events but no new events were derived specifically for loss of power initiating events. In response to RAI 13.2-5 (Reference 17), NWMI stated that the summary of radiological consequences from the analysis of other accidents where loss of power was an initiator will be provided in the FSAR submitted as part of the OL application. The staff is tracking this item in Appendix A of this SER.

Based on its review, the staff finds that the level of detail provided on NWMI's loss of normal electrical power demonstrates an adequate design basis for a preliminary design and satisfies the applicable acceptance criteria of the ISG Augmenting NUREG-1537, Part 2, Section 13b.1, allowing the staff to make the following findings:

(1) All SR-IROFS are designed to fail-safe with a loss of power. Any requirement for emergency cooling or ventilation functions is provided as intended in the production facility design.

(2) The loss of normal electrical power will not result in an unsafe condition for either the production facility workers or members of the public in uncontrolled areas. NWMI PSAR Chapter 8.0, "Electrical Power Systems," describes emergency power to the production facility. The preliminary design shows the use of a safety related uninterruptible power supply to automatically provide power to systems that support safety functions which will protect facility personnel and the public.

Therefore, the staff concludes that NWMI's loss of normal electrical power event, as described in NWMI PSAR Section 13.2.5, is sufficient and meets the applicable regulatory requirements and guidance for the issuance of a construction permit in accordance with 10 CFR Part 50. Further technical or design information required to complete the safety analysis can reasonably be left for later consideration, and will be provided, in the FSAR based on the final design. The staff will confirm that the final design conforms to the design basis during its evaluation of NWMI's FSAR.

13.4.7 Natural Phenomena Events

In NWMI PSAR Section 13.2.6, "Natural Phenomena Events," NWMI identified tornado impact, high straight-line winds, heavy rain, flooding, seismic impact, and heavy snow fall or ice buildup as natural phenomena events that can affect the NWMI production facility. These are treated as design-basis accidents. The NWMI production facility has been designed to survive a design-basis earthquake, tornado and wind loads including missiles, heavy rain and flooding, heavy snow fall and ice buildup, and keep the facility safety functions intact. The only additional IROFS added to address natural phenomena events was FS-04, Irradiated Target Cask Lifting Fixture. This fixture will be designed to prevent the cask from tipping within the fixture and prevent the fixture itself from toppling during a seismic event.

The applicant evaluated the impact of tornadoes on SSCs in NWMI PSAR Section 13.2.6.1, "Tornado Impact on Facility and Structures, Systems, and Components." The evaluation was based on the maximum sized tornado with a return frequency of 10^{-5}/year. A tornado may cause significant impacts to SSCs in the building, loss of power, and directly impact the components that are important to safety. Damage to the structure could impact SSCs important to safety or impact criticality spacing requirements. Tornado missiles could penetrate the building envelope impacting the availability and reliability of IROFS or may lead to radiological or chemical releases. The applicant stated that the return frequency of the design basis tornado is 10^{-5}/year which would make the initiating event highly unlikely and no additional IROFS are required. However, as part of the development of the FSAR, NWMI stated that it will evaluate whether initiating natural phenomena events with returns greater than the selected design basis event could cause a release exceeding 10 CFR Part 70.61 levels and thereby would necessitate IROFS.

The applicant evaluated the impact of high straight-line winds on the facility and SSCs in NWMI PSAR Section 13.2.6.2, “High Straight-Line Winds Impact the Facility and Structures, Systems, and Components.” NWMI states that its evaluation demonstrates how the production facility design addresses straight-line winds with a return interval of 100 years as required by building codes. The production facility is designed as a Category IV structure, in accordance with ASCE 7, “Minimum Design Loads for Buildings and Other Structures.” The construction of the production facility, when used with companion standards such as American Concrete Institute (ACI) 318, “Building Code Requirements for Structural Concrete,” and American Institute of Steel Construction (AISC) 360, “Specifications for Structural Steel Building,” is designed to meet the target maximum annual probabilities established in ASCE 7. The highest probability of failure, which is for a failure that is not sudden and does not lead to wide-spread progression of collapse, for a Category IV structure in ASCE 7 is 5.0×10^{-6}. The applicant states that the use of these codes at the NWMI production facility would render the high straight-line wind event highly unlikely. The staff will confirm that the applicant commits to using these codes as part of its review of the FSAR submitted as part of the OL application for the production facility.

The applicant evaluated the impact of heavy rain on the production facility and SSCs in NWMI PSAR Section 13.2.6.3, “Heavy Rain Impact on Facility and Structures, Systems, and Components.” The NWMI evaluation stated that localized heavy rain can overwhelm the structural integrity of the production facility roofing system. The evaluation determined the impact of the probable maximum precipitation (PMP) in the form of rain on the roof structure. The PMP represents the theoretical worst case of the most precipitation that is physically possible over a particular drainage area over a selected period of time. The applicant stated that the use of the PMP makes the heavy rain impact event highly unlikely. The staff will confirm that the applicant commits to using appropriate structural codes and standards to ensure the integrity of the production facility and SSCs during the review of the FSAR submitted as part of the OL application.

The applicant evaluated flooding impact to the production facility and SSCs in NWMI PSAR Section 13.2.6.4, “Flooding Impact to the Facility and Structures, Systems, and Components.” The site elevation is above the 100-year and 500-year flood plains. Floods beyond the 500-year flood can have an adverse impact on the structure and SSCs within the production facility. The impacts could include structural damage from water, damage to IROFS, and loss of moderation control to prevent criticality. NWMI states that the site will be graded to direct the storm water from localized downpours with a rainfall intensity for a 100-year storm for a 1-hour duration. Based on the location of the site, which is above the 500-year flood plain by 6.1 m (20 ft), NWMI determined that the flooding impact to the facility and SSCs event is highly unlikely. The staff will evaluate the facility grading as part of its review of the FSAR submitted as part of the OL application.

NWMI evaluated the seismic impact to the production facility and SSCs in NWMI PSAR Section 13.2.6.5, “Seismic Impact to the Facility and Structures, Systems, and Components.” A seismic event may impact the production facility structure, IROFS, and the potential for falling components impacting SSCs or causing direct damage to SSCs. Additionally, during irradiated target shipping cask unloading preparations, the shield plug fasteners are removed, which could cause worker radiation exposures if the cask is tipped over during a seismic event while it is being unloaded. Leaks of fissile solution based on damage from a seismic event could lead to a criticality event. An additional IROFS related to the irradiated target cask lifting fixture was included to address the tip over event.

NWMI stated in PSAR Section 13.2.6.5 that it is using NRC Regulatory Guide 1.60, "Design Response Spectra for Seismic Design of Nuclear Power Plants" (Reference 98), for the final seismic design adjusted to reflect the ground acceleration response of 0.2 g. However, as part of the structural analyses of the final design, NWMI stated that they will analyze the impacts of a seismic event on the SR SSCs of the safe shutdown earthquake including the impacts of higher frequency ground motions. NWMI also stated that it will determine the impacts of seismic events with shorter return periods on SR SSCs, in order to determine whether additional IROFS may be needed to prevent or mitigate the impacts of a seismic event on the production facility consistent with the performance objectives of 10 CFR 70.61. This item is being tracked in Appendix A of this SER.

The impact of heavy snow or ice buildup on the production facility and SSCs is evaluated in Section 13.2.6.6, "Heavy Snow Fall or Ice Buildup on Facility and Structures, Systems, and Components," of the NWMI PSAR. Heavy snow or ice buildup could cause a failure of the roof which would impact the ability of SSCs to perform their safety functions. The snow load used by the applicant is the 100-year snowpack, which is equivalent to the design snow load for a Risk Category IV structure determined in accordance with ASCE 7. The provisions of the ASCE standard, when used with companion standards such as ACI 318 and AISC 360, reduce the likelihood of a failure of the structure when subjected to the design snow load in conjunction with other loads as provided by ASCE 7. The applicant states that the use of these codes at the NWMI production facility would render the heavy snow or ice buildup event highly unlikely. The staff will confirm that the applicant commits to using appropriate structural codes and standards to assure integrity of the production facility and SSCs as part of its review of the FSAR submitted as part of the OL application.

Based on its review, the staff finds that the level of detail provided on NWMI's analyzed natural phenomena events demonstrates an adequate design basis for a preliminary design and satisfies the applicable acceptance criteria of the ISG Augmenting NUREG-1537, Part 2, Section 13b.1, allowing the staff to make the following finding:

> The applicant adequately considered the consequences of natural phenomena events for the preliminary design of the production facility. The consequences of natural phenomena events analyzed with respect to the performance requirements of 10 CFR 70.61 demonstrate that the safety and health of workers and the public will be adequately protected.

Therefore, the staff concludes that NWMI's analysis of natural phenomena events for the preliminary design, as described in NWMI PSAR Section 13.2.6, is sufficient and meets the applicable regulatory requirements and guidance for the issuance of a construction permit in accordance with 10 CFR Part 50. Further technical or design information required to complete the safety analysis can reasonably be left for later consideration, and will be provided, in the FSAR based on the final design. The staff will confirm that the final design conforms to the design basis during its evaluation of NWMI's FSAR.

13.4.8 Other Accidents Analyzed

NWMI PSAR Section 13.2.7, "Other Accidents Analyzed," presents the evaluation of all other accidents identified by the PHA as requiring further evaluation. A total of 75 unique accidents are identified and described in NWMI PSAR Table 13-24, “Analyzed Accidents Sequences.” The table lists each accident, a brief description of the accident sequence, and any IROFS identified as necessary to prevent or mitigate the accidents.

NWMI PSAR Table 13-25, “Summary of Items Relied on for Safety Identified by Accident Analyses,” summarizes all IROFS selected to prevent or mitigate the analyzed accidents and identifies whether the IROFS are an engineered safety feature (ESF) or an administrative control.

NWMI PSAR Sections 13.2.7.1 through 13.2.7.4 identify and describe the safety functions of all remaining IROFS not previously selected to reduce the event likelihood and to mitigate the consequences of the bounding postulated accidents.

In response to staff RAI 13.2-8b (Reference 17), NWMI stated that the PHA tables for the NWMI production facility Mo system and waste handling will be updated for the hazards associated with the Mo resin as part of the ongoing ISA process, and will be reflected in the FSAR submitted as part of the OL application. The staff is tracking this issue in Appendix A of this SER.

The staff reviewed the other accidents analyzed events discussion and the ISA accident sequence information in PSAR Tables 13-9, 13-10, 13-11, and 13-12, and finds that the applicant has adequately identified credible accident sequences and potential radiological and chemical consequences at the NWMI production facility.

Based on its review, the staff finds that the level of detail provided on NWMI’s other accidents analyzed events demonstrates an adequate design basis for a preliminary design and satisfies the applicable acceptance criteria of the ISG Augmenting NUREG-1537, Part 2, Section 13b.1, allowing the staff to make the following findings:

- The staff has reasonable assurance that NWMI has described an NCS program that will, if properly implemented, ensure that all facility processes are subcritical under both normal and credible abnormal conditions, and will comply with the double contingency principle. Additional information regarding the review of the criticality safety program can be found in Chapter 6.0 of the SER.

- The applicant adequately considered the consequences of events derived from the preliminary design that may cause either radiological or chemical exposures to workers or the public with respect to the performance objectives of 10 CFR 70.61. The consequences of other potential accidents evaluated by NWMI demonstrate that radiation doses or chemical releases to the public and workers will be within acceptable limits, and the health and safety of workers and the public will be adequately protected.

Therefore, the staff concludes that NWMI’s analysis of the analyzed events for other accidents based on the preliminary design, as described in NWMI PSAR Section 13.2.7, is sufficient and meets the applicable regulatory requirements and guidance for the issuance of a construction permit in accordance with 10 CFR Part 50. Further technical or design information required to complete the safety analysis can reasonably be left for later consideration, and will be provided, in the FSAR based on the final design. The staff will confirm that the final design conforms to the design basis during its evaluation of NWMI’s FSAR.

13.4.9 Analyses of Accidents with Chemical Hazards

The objective of the staff's chemical hazards review of the NWMI PSAR is to determine whether the application demonstrates that the proposed preliminary design is based on a recognition of chemical hazards associated with proposed production facility activities and the design includes appropriate features for managing these hazards. Review of chemical hazards is necessary to determine whether the application meets the requirements of 10 CFR 50.35 for the issuance of a construction permit. In particular, the staff's review determines whether:

(1) The applicant described the proposed design of the facility, including, but not limited to, the principal architectural and engineering criteria for the design, and identified the major features or components incorporated therein for the protection of the health and safety of the public from chemical hazards,

(2) Such further technical and design information related to chemical hazards as may be required to complete the safety analysis, and which may reasonably be left for later consideration, will be supplied in the FSAR,

(3) Safety features or components, if any, related to chemical hazards, and which require research and development, have been described in the application and the applicant has identified and will conduct a research and development program to resolve any safety questions associated with such features or components, and

(4) There is reasonable assurance that such chemical hazard safety questions can be resolved by the date for completion of construction and, taking into consideration the siting criteria, the proposed facility can be constructed and operated at the proposed location without undue risk to the health and safety of the public.

The review focused on the NWMI production facility that is to be licensed under the regulations of 10 CFR Part 50. PSAR information on the target fabrication activity, that NWMI stated it will submit a separate 10 CFR Part 70 application, was examined to determine whether operations in this area could introduce chemical hazards that significantly increased the chemical hazards for the NWMI production facility licensed under the regulations of 10 CFR Part 50. The staff used its engineering judgment to determine the extent that established guidance and acceptance criteria were relevant to the review of NWMI's construction permit application, as much of this guidance was originally developed for completed designs of nuclear reactors.

The staff reviewed the proposed NWMI production facility and operations described in the PSAR for the purpose of understanding chemical hazards that could impact the health and safety of the workers and the public. The staff examined the preliminary process description information including the chemical composition, temperature, and flow rate of process streams; information on preliminary process equipment sizes; information on the identification and analysis of chemical hazards including estimated consequences; and information on identified ESFs designed to keep exposure to workers and the public within acceptable values.

The process information is presented in Chapter 4.0 of the PSAR. The staff's review examined chemicals used in the processes and process materials. The review examined potential effects of direct release of hazardous chemicals as well as the potential for energetic chemical reactions that could release radioactive or chemically hazardous materials. While the process description information primarily described normal operations, the staff review also considered events that might occur in other operating modes including maintenance and extended shutdown.

The staff examined the location of the various process operations in the NWMI production facility and the location and size of process equipment in the various cells. The staff noted that dissolver and Mo-purification operations are conducted in limited volume cells with shielding, viewing windows, and manipulators. The staff also noted that the offgas treatment equipment that would retain volatile radionuclides as well as the uranium purification equipment are contained in the shielded and remotely operated and maintained tank hot cell.

The staff reviewed the literature on accidents that have occurred or have been postulated for similar operations. The staff made independent process calculations, such as uranium dissolution rates and material balances, as part of its review. The information describing the process made it clear to the staff that some proposed operations (e.g., target dissolution) would increase the potential for releasing radionuclides that could impact workers or the public. The chemical process operations could involve process upsets or equipment failures leading to releases of chemical or radiological materials. The review found that some portions of the processes have the potential for energetic reactions that could release and disperse larger quantities of chemically toxic or radioactive material.

The staff reviewed the NWMI-identified accidents focusing on those that could be initiated by or involve chemical hazards. These are described in Chapter 13.0 of the NWMI PSAR and in the ISA Summary. NWMI PSAR Chapter 13.0 identified and described the potential accidents that could be initiated by several types of events including loss of electrical power, external events, equipment malfunction, and operator error.

Hazards identified and analyzed by NWMI and reviewed by the staff because of their potential chemical hazard initiator include:

- Multiple scenarios involving the accumulation of flammable gas, such as hydrogen, in tanks or systems. The general accident sequence was labeled S.F.02 and was identified for target fabrication, target dissolution, Mo recovery, uranium recovery and waste handling processes. An IROFS, FS-03, the process vessel emergency purge system, was identified by NWMI for the general accident sequence. This system is also identified as part of an ESF in Chapter 6.0 of the PSAR.

- Multiple scenarios for damage to the process ventilation system due to cooling failure or fire in the reduction furnace. The general accident sequence was labeled S.F.04 and was identified for the target fabrication area. No IROFS were identified for the accident sequence.

- Multiple scenarios leading to a fire in the carbon retention bed. The description states that fire develops through exothermic reaction to contaminants in the carbon retention bed (NWMI PSAR Table 13-10). The general accident sequences was labeled S.F.05 and was identified for the target dissolution and ventilation system areas. An IROFS, FS-05, the exhaust stack height, was identified for the general accident sequence. This feature is also identified as an ESF in Chapter 6.0 of the NWMI PSAR.

- Multiple scenarios that could lead to the accumulation of combustible gas in ventilation system components. The consequences are characterized as a potential detonation or deflagration (NWMI PSAR Table 13-15). The general accident sequence was labeled S.F.06 and was identified for the ventilation system. No IROFS were identified. However, S.F.02 was considered to be a bounding sequence.

- Multiple scenarios involving fire in the nitrate extraction system. The general accident sequence was labeled S.F.07 and was identified for the target fabrication area. No IROFS were identified for the accident sequence.

- Multiple scenarios involving a non-mechanistic spray release leading to increased radiological release rate. The description mentioned deflagration as a potential mechanism. The general accident sequence was labeled S.R.03 and was identified for target fabrication, target dissolution, Mo recovery, uranium recovery, and waste handling areas. No IROFS were identified. However, a solution spill in S.R.01 was considered to be a bounding sequence.

- Multiple scenarios where liquid or vapor would enter the process vessel ventilation system and damage the iodine retention unit leading to increased radiological release rate. The general accident sequence was labeled S.R.04 and was identified for target fabrication, target dissolution, Mo recovery, uranium recovery, waste handling, and the ventilation areas. Two IROFS were identified, RS-09, the Primary Offgas Relief System, and RS-03, the Hot Cell Secondary Confinement Boundary. These features are identified as part of an ESF in Chapter 6.0 of the NWMI PSAR.

- Multiple scenarios that could lead to loss of temperature control in the iodine retention unit leading to increased radiological release rate. The general accident sequence was labeled S.R.07 and was identified for the target dissolution area. No IROFS were identified. However, a fire in the iodine retention unit in S.R.04 was considered to be a bounding sequence.

- Multiple scenarios that could lead to loss of the iodine retention material leading to increased radiological release rate. The general accident sequence was labeled S.R.09 and was identified for the target dissolution area. No IROFS were identified. However, a fire in the iodine retention unit in S.R.04 was considered to be a bounding sequence.

- Multiple scenarios that involve a reaction with ion exchange resin where the PSAR stated that the consequences are not fully understood. The general accident sequence was labeled S.R.14 and was identified for the uranium recovery area and the accident sequence was identified as requiring further evaluation. No IROFS were identified. However, a solution spill in S.R.01 was considered to be a bounding sequence.

- Two scenarios where chemical burns occurred during sample analysis activities. The general accident sequence was labeled S.R.31 and was identified for the analytical laboratory. No IROFS were identified for the accident sequence.

- One scenario resulting in nitric acid inhalation. The accident sequence was labeled S.CS.01 and was associated with the chemical preparation and storage room. No IROFS were identified for the accident sequence.

- Several non-mechanistic chemical releases were analyzed in NWMI PSAR Chapter 19.0, “Environmental Review.” The accident scenarios were identified for the bulk chemical handling area. The analysis estimated impacts for the maximally exposed off-site individual and the nearest resident. The chemicals with the greatest impact were nitric acid and ammonia.

The PSAR presented radiological consequence estimates for a limited number of accidents that the staff considers could be initiated by or involve chemical hazards. These were:

- Accident involving iodine release, as described in NWMI PSAR Section 13.2.3, which appears to be consistent with accident sequence S.R.04. The accident involved the release of the iodine inventory from four targets irradiated in the MURR. The PSAR estimated the maximum total effective dose equivalent from such a release as 0.2 rem at 100 m (328 ft) from the stack (NWMI PSAR Table 13-22, “Target Dissolver Offgas Accident Total Effective Dose Equivalent”).

  The staff reviewed the NWMI calculations and made independent RASCAL (Radioisotope Assessment System for Consequence Analysis) runs using similar input parameters (e.g., source term release rate, meteorology). The staff developed comparable dose estimates for downwind receptors. The analysis demonstrates the importance of process equipment (e.g., NOx scrubber, IRU) that limit radionuclide releases to the atmosphere and therefore limit doses to downwind receptors.

- Accidents involving a generic spray release, as described in NWMI PSAR Section 13.2.2.7.2, which the staff noted appear to be consistent with accident sequence S.R.03. The consequence analysis considered the effects of a 100 liters (26 gallons) spray leak considering both unmitigated and mitigated conditions. The mitigated scenario involved a reduction in the leak path factor by a factor of 10 for iodine and 2,000 for non-iodine, non-noble gas constituents NWMI PSAR Table 13-19, “Release Consequence Evaluation RASCAL Code Inputs.” The reduction in leak path factor is tied to gravitational settling associated with airflow through the facility and the removal action of high-efficiency particulate air filtration. For a spray involving dissolver product with a high fission product concentration, the NWMI analysis predicts an unmitigated dose of 300 mrem at 432 m (1,417 ft) and 1.8 rem at 1,100 m (3,608 ft).

  The staff reviewed the NWMI calculations and made independent RASCAL runs for the unmitigated scenario and obtained comparable results. The analysis shows the importance of structural features and the ventilation system (i.e., confinement features) to reduce the leakage of material from the NWMI production facility to the environment. The staff noted that the NWMI discussion of this consequence analysis identifies three IROFS which are linked to the confinement ESFs presented in NWMI PSAR Table 6-1, “Summary of Confinement Engineered Safety Features.”

The staff finds that the NWMI accident analysis covered a broad spectrum of accidents in a general, high-level manner that is sufficient for a construction permit. The information was used by NWMI to identify ESFs or controls such as IROFS that mitigate accident consequences. The staff finds that the level of the analysis is consistent with the preliminary nature of the process, process equipment design, and facility design. The staff notes that the PSAR and responses to RAIs identify information that will be updated for the OL application. The updated analysis in the FSAR, based on the final design, will include controls such as IROFS and TSs that will function to prevent or mitigate production facility accidents. The staff is tracking items, including the identification of TSs needed to prevent or mitigate the consequences of chemical accidents, in Appendix A of this SER.

In response to RAI 13.2-10 (Reference 17), NWMI stated that additional information on specific features of the NWMI production facility to prevent and/or mitigate nitric acid fume releases will be included in the FSAR as part of the OL application. The staff is tracking this item in Appendix A of this SER.

The staff found that the analysis of energetic chemical hazards in the PSAR was limited. While the NWMI PSAR stated in Section 13.1.1.2, "Accident Consequence Analysis," that the hazard analysis would address "fires and explosions associated with chemical reactions," such hazards were not specifically identified or analyzed. NWMI PSAR Table 13-12 describes the potential for high temperature reagents to cause unknown impacts on the uranium ion exchange resin. The PSAR states that this accident would have to be further researched. The PSAR did not discuss the potential for energetic reactions with the Mo-purification ion exchange material or the potential for red-oil-like hazard associated with diamyl-amyl phosphonate (DAAP) used in the uranium purification system. The NWMI response to staff RAI 13.1-2c (Reference 31) discussed NWMI's plans for research and development related to the uranium ion exchange system. The staff is tracking this item in Appendix A of this SER. In order to determine the impact of deferring this evaluation until the OL, the staff conducted independent analysis of chemical hazards that could result in larger releases of activity and/or energetic reactions that could damage equipment or ESFs and injure nearby personnel. The purpose of the analysis was to gain insight into the significance of the potential accidents using preliminary design information.

The specific energetic hazards examined were (1) reactions involving organic anion exchange media for Mo-99 purification, and (2) reactions involving organic ion exchange media used for uranium purification.

(1) NWMI PSAR Table 4-42, "Strong Basic Anion Exchange Column Cycle," identifies the use of a strongly basic anion exchange resin for the second Mo purification cycle. Organic anion exchange material is a recognized hazard when combined with oxidizing material such as nitric acid. The hazard in the NWMI case appears to be reduced because of small column size (Column MR-IX-225), and the elution solution (NWMI PSAR Table 4-42). As described in NWMI PSAR Section 4.3.5.2, "Process Equipment Arrangement," the columns are cooled and the equipment is located in the thick-walled Mo Recovery Hot Cell (H106).

    An evaluation of the potential damage from an ion exchange exothermic reaction was made using a correlation that related "scaled distance" for trinitrotoluene (TNT)-equivalent explosion to "side-on" overpressure that the nearest confinement barrier would experience. This correlation between scaled distance and overpressure is commonly found in the literature evaluating the effects of explosions.[1] SER Figure 13.4.10-1, "Scaled Distance-Overpressure Relationship," shows this distance-overpressure relationship. The use of this relationship is generally considered to be conservative because the energetic ion exchange reactions can often proceed at a slower, non-explosive rate resulting in reduced overpressures.

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[1] Methods for the calculation of physical effect, "Yellow Book," Committee for the Prevention of Disasters, third edition, 2005, Chapter 5. Section 5.3.2 discusses an approach of using an equivalent TNT mass and scaled distance to predict peak side-on overpressure.

Using this approach requires a relationship between material involved in a reaction and its TNT equivalent. For the materials of interest in this effort, factors relating mass of process material to mass of TNT were drawn from an NRC-sponsored research report prepared by Pacific Northwest Laboratory.[2] The staff tested the reasonableness of this approach by applying it to an Americium ion exchange column deflagration that occurred at the Hanford site.[3,4] The staff found that this approach produced an overpressure estimate for the Hanford event that was consistent with previous, more detailed analysis conducted for that event.[5]

The scaled distance is the distance (meters (m)) between the reaction source and the object of interest (e.g., a cell wall) divided by the cube root of the TNT mass equivalent (kilogram (kg)). The estimated column volume for the Mo ion exchange system is 0.2 liters (0.05 gallons) and the estimated energy equivalent for ion exchange resin based on Halverson and Mishima is 0.1 lb (0.045 kg) of TNT per cubic foot of material. This equates to a TNT equivalent of 0.00032 kg. Estimating the distance between the ion exchange column and the cell wall near the operator to be 18 inches (0.45 m) based on information in the PSAR, the scaled distance for the postulated Mo purification ion exchange deflagration event is 6.7 $m/kg^{1/3}$. The estimated side-on overpressure for this postulated event is about 0.36 bar (5.2 pounds per square inch (psi)). This pressure reduces rapidly with distance from the deflagration point.

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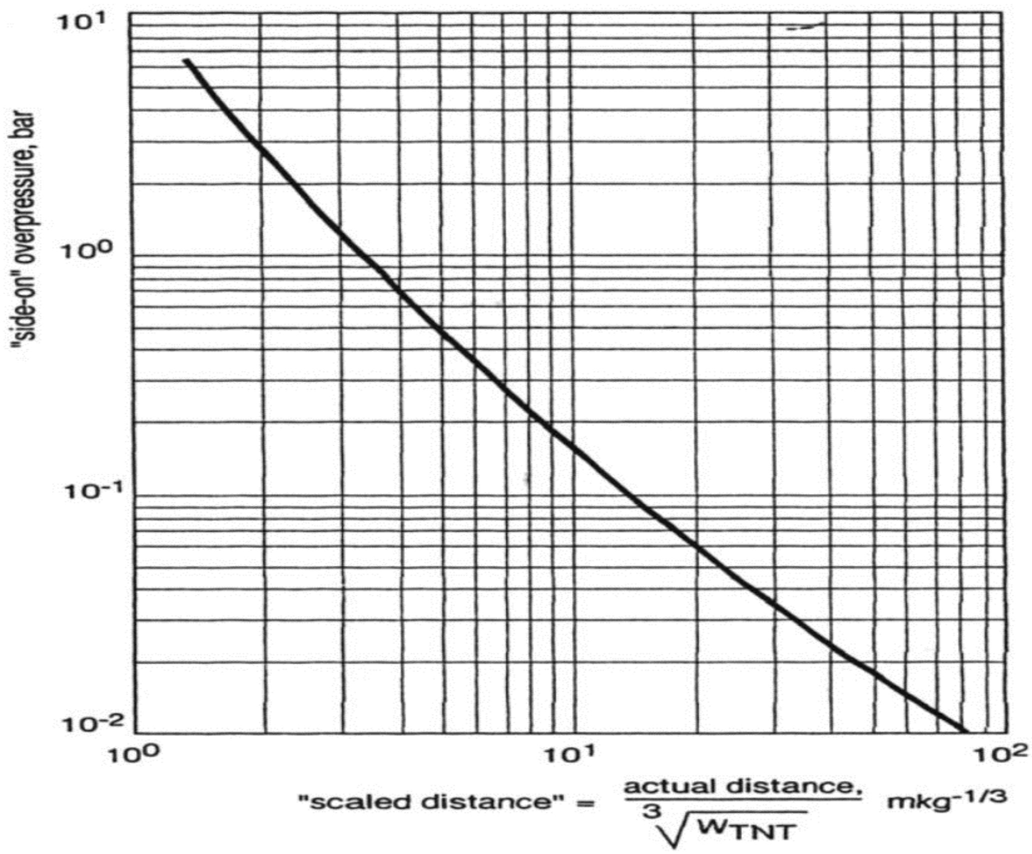
[2] M.A. Halverson and J. Mishima, Initial Concepts on Energetics and Mass Releases During Nonnuclear Explosive Events in Fuel Cycle Facilities, NUREG/CR-4593, PNL-5839, 1986.

[3] "Explosion of Cation Exchange Column in Americium Recovery Service, Hanford Plant, August 30, 1975," BNWI-1006, October 8, 1976.

[4] "Investigation of the Chemical Explosion of an Ion Exchange Resin Column and Resulting Americium Contamination of Personnel in the 242-Z Building," August 30, 1976, Energy Research and Development Administration, BNWI-1007-DEL, October 19, 1976.

[5] C. Grelecki, "Investigation of Incident in Ion Exchange Resin," HRC Report 3719, September 21, 1976 (Appendix 4 to BMWI-1006 cited above)

Figure 13.4.10-1 Scaled Distance-Overpressure Relationship



NWMI PSAR Section 4.2.3.5, "Estimated Hot Cell Wall Thickness," describes the Mo recovery and purification cell as a walled concrete structure that is approximately 4 feet thick. It is expected that the hot cell wall will be able to withstand a 5 psi pressure pulse from the reaction of the organic Mo recovery column. This assessment is based on the finding that the peak overpressure in the glovebox for the Hanford ion exchange event was in the range of ten to a few tens of psi and it did not lead to failure of the glove box. The pressure caused glass windows on the glovebox to fail. There were some bulges on the side and top of the glovebox near the ion exchange column. The estimated Mo ion exchange overpressure is less than half of that estimated to have occurred in the Hanford incident and the enclosure is more substantial.

The analysis shows the importance of ion exchange mass, the distance from the ion exchange column, and the cell wall thickness in limiting accident consequences.

The staff requested additional information in RAI 13.2-8a (Reference 13) regarding NWMI's assessment of this hazard. In response to RAI 13.2-8a (Reference 31), NWMI stated that the ion exchange column was very small and single use. NWMI stated that after elution and rinsing, the column and resin are discarded as waste. NWMI also stated that the process hazard analysis for the Mo system and waste handling will be updated for hazards associated with the Mo resin and will be reflected in FSAR in the OL application. The staff is tracking this item in Appendix A of this SER.

(2) The PSAR identifies the use of an ion exchange media in the uranium recovery system. There are two cycles of ion exchange for uranium purification with each cycle having 2 ion exchange columns (UR-IX-240/260 and UR-IX-260/480; NWMI PSAR Table 4-50, "Uranium Recovery and Recycle Process Equipment"). The ion exchange material has DAAP as an essential ingredient. Uranium that is eluted from the ion exchange system is concentrated in an evaporator following each purification cycle.

A study on the thermal decomposition of DAAP indicates that a red-oil-like phenomena might be possible with DAAP.[6] This study shows an initial exothermic reaction at approximately 380 ^{o}Kelvin (K) (107 Celsius (^{o}C)/210 Fahrenheit (^{o}F)) and a second one at approximately 570 ^{o}K (297 ^{o}C/570 ^{o}F). If DAAP were to enter the concentrator as a result of resin carryover, the potential for an exothermic reaction in the evaporators may exist.

Two energetic events were postulated and analyzed by the staff. The first was a reaction in an ion exchange column and the second was a "red oil" type reaction in an evaporator. For the ion exchange column reaction analysis, the closest distance between a uranium ion exchange column and a tank hot cell wall is estimated to be 12 ft (3.65 m) based on dimensional information presented in NWMI PSAR Figures 4-4 and 4-76. For the evaporator analysis, the volume of the evaporator feed tank (NWMI PSAR Table 4-50) was used to estimated distance between the closest tank hot cell wall and the evaporator 4.5 ft (1.372 m).

Assuming the volume of ion exchange resin in the column (derived from Table 4-49, "First-Cycle Uranium Recovery Ion Exchange Column Cycle Summary"), and the density of the resin of about 1g/cc, the maximum potential TNT equivalent for a uranium purification column is 0.053 kg. The scaled distance for the ion exchange column is 9.8 $m/kg^{1/3}$. This would produce a side-on pressure of 0.2 bar or about 3 psi.

The amount of DAAP that could be involved in a concentrator "red oil" event is not discussed in the PSAR. The staff analyzed the transfer of 25 percent of a column inventory. This would be equivalent to 0.013 kg. The scaled distance for the evaporator is thus estimated to be 5.9 $m/kg^{1/3}$. This analysis indicates that the evaporator with its lower scaled distance is a greater hazard than that postulated for the ion exchange column accident because the evaporator is closer to the tank hot cell wall. The "on-side" overpressure associated with the postulated concentrator event is estimated to be 0.44 bar (6.4 psi).

The tank hot cell is estimated to have a wall thickness of 4 feet based on information in NWMI PSAR Figure 4-76, "Tank Hot Cell Equipment Arrangement." For the reasons mentioned when discussing deflagration within the Mo recovery and purification cell, the staff does not expect that deflagrations in the uranium purification system would result in leakage of hazardous material into worker occupied areas.

The staff requested additional information on NWMI's assessment of this hazard. In response to RAI 13.1-2 (Reference 31), NWMI stated that it was evaluating the adequacy of a pressure relief system for mitigating a potential accident resulting in exothermic reactions of the uranium ion exchange material. NWMI also stated that

[6] C.V.S Brahmmananda Rao et. al., "Thermodynamics and kinetics of thermal decomposition of diamylamyl phosphonate-nitric acid systems," Thermochimica Acta, 545 (2012), 116-124.

release of DAAP from ion exchange media during operation would be evaluated as part of the research and development program. The staff is tracking this item in Appendix A of this SER.

In order to support the review of PSAR accident scenarios and the preliminary IROFS, the staff reviewed the ESFs presented in Chapter 6.0 of the PSAR. The staff reviewed the ESFs and considered how they might function in mitigating the effects of accidents involving chemical hazards, both toxic material and energetic chemical processes.

In NWMI PSAR Section 6.1, "Summary Description," NWMI describes the ESFs as active or passive features designed to keep radiological exposure to workers and the public within acceptable values. NWMI PSAR Table 6-1 identifies the confinement ESFs and the associated SSC that provides the ESF. The PSAR states that SSCs important safety are those elements that provide reasonable assurance that the facility can be operated without undue risk to the health and safety of workers and the public.

SER Table 13.4.10-1 presents the NWMI-identified ESFs that the staff considers important for mitigating the effects of potential accidents involving chemical hazards. The second column of the table presents the NWMI-identified SSCs that provide the ESF.

The staff reviewed the design criteria that NWMI was applying to the ESFs identified in SER Table 13.4.10-1. The staff finds that the ESFs identified in SER Table 13.4.10-1 would be effective in protecting the health and safety of workers and the public from chemical hazards if the ESFs were adequately designed and constructed. The staff did not identify any major hazards where accident consequences would not be mitigated by the ESFs.

The NWMI application identified principal architectural and engineering criteria for the NWMI production facility including design basis loads for the facility. The design basis wind loads for the facility is identified in NWMI PSAR Section 3.2.4, "Wind Load," and includes straight-line winds of 120 miles per hour (mph) (1,700-year recurrence interval) and tornado winds of 230 mph. The design basis seismic event is a spectrum anchored to 0.2 g peak ground acceleration as identified in NWMI PSAR Section 3.4.1.1, "Design Response Spectra."

NWMI PSAR Table 3-24, "System Safety and Seismic Classification and Associated Quality Level Group," states that the systems that contain the ESFs identified in SER Table 13.4.10-1 are classified as seismic category C-I systems. The staff finds this acceptable.

Table 13.4.10-1 Engineered Safety Features that Support Chemical Safety

Confinement ESF (Section 6.2.1)	SSCs providing ESFs (Table 6-1)
Hot cell liquid confinement boundary Hot cell secondary confinement boundary Hot cell shielding boundary	• Confinement enclosures including penetration seals • Zone I exhaust ventilation system, including ducting, filters, and exhaust stack • Zone I inlet ventilation system, including ducting, filters and bubble-tight isolation dampers • Ventilation system control • Secondary iodine removal bed • Berms
Primary offgas relief system	• Pressure relief device • Pressure relief tank
Process vessel emergency purge system	• Backup bottled nitrogen gas supply
Dissolver offgas iodine removal units	• Dissolver offgas iodine removal units (DS-SB-600A/B/C)
Dissolver offgas primary absorber	• Dissolver offgas primary absorber units (DS-SB-620A/B/C)
Dissolver offgas vacuum receiver/ vacuum pump	• Dissolver offgas vacuum receiver tanks (DS-TK-700A/B) • Dissolver offgas vacuum pumps (DS-P-710A/B)
Exhaust stack height	• Zone I exhaust stack

The staff finds that the PSAR adequately describes the proposed design of the NWMI production facility for the purposes of a construction permit application, and identified the major features or components incorporated therein for the protection of the health and safety of the public and workers from chemical hazards. These major features or components are the ESFs/SSCs which NWMI identified in the PSAR and are listed in SER Table 13.4.10-1 presented above. These ESFs will be designed as seismic category C-I systems.

NWMI identified ESFs and SCCs based on the preliminary accident analysis and ISA in its application. The staff finds that the identification of these features listed in SER Table 13.4.10-1 and the classification of them as being safety related systems is acceptable, based on the staff's review of the process description, the production facility equipment and design and the NWMI accident analysis/ISA, as well as the staff's independent analysis.

The staff finds that NWMI adequately identified the principal architectural and engineering criteria for the facility and the major features, such as ESFs, incorporated into the design for the protection of the health and safety of the public and workers from chemical hazards. The staff finds that this meets the criteria in 50.35(a)(1) for issuing a construction permit.

In response to RAI 13.3-2 (Reference 31), NWMI states that it will provide final design and safety analysis in the FSAR, including detailed and specific analysis of chemical accidents that will support its OL application (the staff is tracking these issues in Appendix A of this SER). The staff finds that this meets the criteria in 50.35(a)(2) for issuing a construction permit.

NWMI has identified chemical safety research and development that it will be conducting to resolve chemical safety questions related to uranium purification (the staff is also tracking these issues in Appendix A of this SER). The staff finds that this meets the criteria in 50.35(a)(3) for issuing a construction permit.

The staff finds that it has reasonable assurance that the chemical safety questions related to uranium purification can be resolved before completion of construction. Additionally, considering the siting criteria, the proposed production facility can be constructed and operated at the proposed location without undue risk to the health and safety of workers and the public from chemical hazards. This meets the criteria in 50.35(a)(4) for issuing a construction permit.

Therefore, the staff concludes that NWMI's analysis of accidents with chemical hazards for the preliminary design, as described in NWMI PSAR Section 13.3, is sufficient and meets the applicable regulatory requirements and guidance for the issuance of a construction permit in accordance with 10 CFR Part 50. Further technical or design information required to complete the safety analysis can reasonably be left for later consideration, and will be provided in the FSAR based on the final design. The staff will confirm that the final design conforms to the design basis during its evaluation of NWMI's FSAR.

13.4.10 Probable Subjects of Technical Specifications

In accordance with 10 CFR 50.34(a)(5), the staff evaluated the sufficiency of the applicant's identification and justification for the selection of those variables, conditions, or other items which are determined to be probable subjects of TSs for the NWMI production facility with special attention given to those items which may significantly influence the final design.

The NWMI PSAR Chapter 14.0, "Technical Specifications," states that the NWMI facility ISA process identified SSCs that are defined as IROFS. The importance of these SSCs will also be reflected in the TSs. Each IROFS will be examined and likely translated into a limiting condition for operation (LCO). This translation will involve identifying the most appropriate specification to ensure operability and a corresponding surveillance periodicity for the IROFS.

In response to RAI 13.2-9a (Reference 31), NWMI states that, because maintenance activities (i.e., removing a cover block to replace a piece of failed equipment) could change the configuration of the facility, the TSs, which will be provided as part of the OL application, will include limits on operations activities or acceptable inventories. The staff is tracking this item in Appendix A of this SER.

The PSAR also provides an outline for the TSs that will be prepared during the development of the OL application. This outline includes actions, administrative controls, LCOs, limiting safety system settings, safety limits, and surveillance requirements.

NWMI PSAR Chapter 14.0, Table 11, "Potential Technical Specifications," includes the potential items or variables that are expected topics of TSs. The staff documented its review of NWMI's probable subjects of TSs for the facility in Chapter 14.0, of this SER.

13.5 <u>Summary and Conclusions</u>

The staff evaluated the descriptions and discussions of NWMI's accident analysis, including probable subjects of TSs, as described in NWMI PSAR Chapter 13.0 and supplemented by the applicant's responses to RAIs, and finds that the accident analysis of the preliminary design, including the principal design criteria; design bases; information relative to materials of construction, general arrangement, and approximate dimensions; and preliminary analysis and evaluation of the design and performance of SSCs of the facility: (1) provides reasonable assurance that the final design will conform to the design basis, (2) includes an adequate margin of safety, (3) demonstrates reasonable assurance that SSCs adequately provide for the prevention of accidents and the mitigation of consequences of accidents for the preliminary design, and (4) meets all applicable regulatory requirements and acceptance criteria in or referenced in the ISG Augmenting NUREG-1537, Part 2 for the issuance of a construction permit.

The staff further finds that NWMI PSAR Chapter 13.0 contains sufficient information to conclude that the ESFs would be expected to function as designed to perform their safety functions, and radioactive and chemical hazards associated with SNM can be prevented or mitigated to levels that are acceptable. Realistic, but conservative, methods were used to compute or estimate potential doses and dose commitments to the public in uncontrolled areas and to compute external radiation doses and dose commitments resulting from inhalation by the facility workers. Methods of calculating doses from inhalation or ingestion (or both) and direct exposure to gamma rays from dispersing plumes of airborne radioactive material are applicable and no less conservative than those developed in NWMI PSAR Chapter 11.0, “Radiation Protection and Waste Management.”

Based on these findings, the staff concludes the following regarding the issuance of a construction permit in accordance with 10 CFR Part 50:

(1) NWMI has described the proposed design of the systems supporting the accident analysis, including, but not limited to, the principal architectural and engineering criteria for the design, and has identified the major features or components incorporated therein for the protection of the health and safety of the public.

(2) Such further technical or design information as may be required to complete the safety analysis, and which can reasonably be left for later consideration, will be supplied in the FSAR.

(3) Safety features or components, if any, which require research and development have been described by NWMI and a research and development program reasonably designed to resolve any safety questions associated with such features or components.

(4) On the basis of the foregoing, there is reasonable assurance that: (i) safety questions will be satisfactorily resolved at or before the latest date stated in the application for completion of construction of the proposed facility, and (ii) taking into consideration the site criteria contained in 10 CFR Part 100 the proposed production facility can be constructed and operated at the proposed location without undue risk to the health and safety of the public.