INTERIM STAFF GUIDANCE FCSE-ISG-15: NATURAL PHENOMENA HAZARDS IN FUEL CYCLE FACILITIES

Purpose

The staff is issuing this interim staff guidance (ISG) to provide additional guidance for evaluating events that may result from natural phenomena hazards (NPH). The staff is required to assure compliance with Title 10 of *the Code of Federal Regulations* (10 CFR) Part 70, "Domestic Licensing of Special Nuclear Material," Subpart H, "Additional Requirements for Certain Licensees Authorized To Possess a Critical Mass of Special Nuclear Material." This guidance provides criteria and methods that the staff can use to review the treatment of NPH at fuel cycle facilities as evaluated in the facility integrated safety analysis (ISA) and described in the license application.

Regulatory Framework

For facilities regulated under 10 CFR Part 70, Subpart H, 10 CFR 70.62(c)(1) requires, in part, that each licensee conduct and maintain an ISA that is of appropriate detail for the complexity of the process and that identifies, among other things, "potential accident sequences caused by process deviations or other events internal to the facility and credible external events, including natural phenomena." The regulations in 10 CFR 70.62(c)(1) also require, in part, that each licensee or applicant identify the consequences and the likelihood of occurrence of each potential accident sequence and the methods used to determine the consequences and likelihoods.

The regulations in 10 CFR 70.61, "Performance requirements," requires, in part, that individual accident sequences resulting in high consequences to workers and the public be "highly unlikely" and that sequences resulting in intermediate consequences to these receptors be "unlikely."

For new facilities or new processes at existing facilities, 10 CFR 70.64(a)(2), "Natural phenomena hazards," requires that the design must provide for adequate protection against natural phenomena with consideration of the most severe documented historical events for the site.

Discussion

The staff is issuing this ISG to provide additional guidance to the NRC staff for the review of fuel cycle facilities ISA evaluation of accident sequences that may result from NPH. . This ISG will be incorporated into future revisions of Appendix D of Chapter 3 of NUREG-1520, "Standard Review Plan for the Review of a License Application for a Fuel Cycle Facility." Specific emphasis was provided on seismic hazards due to recent events such as the Fukushima Dai-ichi accident and recent updates to the U.S. Geological Survey hazard curves.

The purposes of the review of a licensee or applicant's treatment of NPH are to support findings that the licensee's safety program and facility, equipment, and procedures are sufficient to provide reasonable assurance that the performance requirements of 10 CFR 70.61, and other

regulatory requirements can and will be met. 10 CFR 70.61 requires that credible high consequence events be "highly unlikely" and credible intermediate consequence events be "unlikely". 10 CFR 70.62(a)(2) requires the licensee to develop and maintain the information that demonstrates that these requirements are met. This licensee evaluation involves identifying accident sequences, which start with an initiating event, intermediate failure events (usually of item relied on for safety (IROFS) or structures) leading to a particular accident, often a release of hazardous material, identifying the consequences of the accident, and the overall likelihood of the accident sequence. The next step is to determine that the performance requirements have been met. Typically for NPH this involves showing that either (a) the frequency of the NPH is less than $1x10^{-6}$ per year (NPH is not credible for location i.e., hurricanes in Washington state), or (b) that failures induced by the NPH that can cause high consequences are "highly unlikely" or intermediate consequences are "unlikely." The acceptance criteria for unlikely and highly unlikely are addressed in the guidance provided in Chapter 3 of NUREG-1520, Revision 1, "Standard Review Plan for the Review of a License Application for a Fuel Cycle Facility." For each natural hazard phenomenon a frequency versus magnitude typically can be obtained, from which the applicant's ISA can relate likelihood to the magnitude of that phenomenon that can cause an event leading to high or intermediate consequences.

Additionally, implementation of 10 CFR Part 70 requirements for existing facilities may vary because of different definitions of likelihood proposed by licensees to comply with 10 CFR 70.65(b)(9). Chapter 3 of NUREG-1520 describes the acceptance criteria for licensee- and applicant-proposed definitions of the terms highly unlikely and unlikely as they apply to the development and maintenance of the ISA. The staff review should include an assessment of the implementation of the definitions of likelihood in the ISA for natural phenomena events. The staff's review should focus on ensuring that the definitions are consistent with accepted standards associated with each natural phenomena event. The implementation of the definitions of highly unlikely and unlikely may differ for each natural phenomena event, as applicable. However, there are several factors that should be considered when evaluating how licensees both define and implement unlikely and highly unlikely for natural phenomena events within the ISA. This is because there is no common approach to determine how probabilistic hazards are determined for various NPH and because different natural phenomena present a unique set of hazards to each facility. Therefore, the resulting performance of the facility under the various NPH and the contribution to overall risk should be considered.

For example, some structures at existing fuel cycle facilities were built to a building code with design-basis earthquake having exceedance probabilities of $2x10^{-3}$ per year to less than $1x10^{-3}$ per year. The current building code uses ground motions with a $4x10^{-4}$ annual exceedance probability. In contrast, standard building codes and industry standards require seismic designs based on probabilistic ground motions with 10 percent probability of exceedance in 50 years or 2 percent probability of exceedance in 50 years.

Guidance For Evaluation Of NPH ISA Events For Fuel Cycle Facilities

The guidance in "Seismic Hazards" in Appendix D of NUREG-1520 provides factors for evaluating earthquake-related events. Another factor to consider is the likely rate of release based on the damage sustained. For example, some facilities may lose dynamic confinement but maintain building integrity. In some processes, radiologically and/or chemically hazardous material is held inside its primary containment at subatmospheric pressure. Furthermore, an

earthquake that results in limited subatmospheric containment losses may allow adequately trained workers to evacuate and/or take mitigative actions. In other cases, buildings may be equipped with a seismically activated interlock (an IROFS) that will shut off the building's heating, ventilation, and air conditioning system during an event, thus limiting any leakage of UF_6 to the outside.

The majority of fuel cycle licensees completed their ISAs after Subpart H of 10 CFR Part 70 was promulgated[1] in September 2000. These ISAs, in general, postulated that structures, systems and components (SSCs) will remain intact during credible seismic events. In some cases, it was concluded that a high radiological or chemical consequence was highly unlikely based on the assumption that the SSCs will adequately perform their safety functions during postulated NPH events. The staff should review the basis for the assumptions used in the ISA to ensure that adequate documentation (e.g., design basis information) exists to support the expected performance of SSCs and/or potential consequences of failures of SSCs.

The license application and ISA must address natural phenomena events (e.g., tornadoes, hurricanes, and earthquakes) and other external events with a sufficient level of detail to characterize and assess their impact on facility safety and compliance with the requirements of 10 CFR 70.61. The licensee's assessment should indicate which events are considered to be not credible or highly unlikely and the basis for that determination. This assessment should also indicate which events could occur without adversely impacting safety and the basis for that determination. In order to comply with the regulatory requirements to prevent or mitigate the consequences of NPHs, licensees may need to maintain access to or possess equipment that is capable of limiting the consequences to public and worker health and safety in the event of multiple credible challenges and degraded or disabled resources. These protective measures could include long-term loss of functions, such as offsite power, onsite emergency power, offsite water supply, other offsite services, and transportation to access offsite resources. The licensee's assessment should also identify the assumptions such as the design bases for the SSCs credited for prevention or mitigation of the consequences to the facility for these types of events.

In order to meet the requirements of 10 CFR 70.62(c)(1), licensees should also evaluate the completeness of events as discussed in the ISA if current information about NPHs indicates that unanalyzed events may be credible and result in accidents that exceed the performance requirements of 70.61. The staff's review should assure that the description of the site and the facility, the design basis, the underlying data, and the assumptions are appropriate to the current condition of the facility as documented in the current ISA.

Evaluation of Structures and Components

Licensees' safety analyses or licensing and design bases should consider credible NPHs. As previously discussed, licensees should also evaluate the completeness of events as discussed in the ISA if current information about NPHs indicates that unanalyzed events may be credible.

[1] Refer to 10 CFR 70.62(c)(3) which required, in part, that existing licensees submit for NRC approval, by April 2001, a plan that described the ISA approach; and by October 2004, or in accordance with the approved plan, a completed ISA. It also required licensees to identify performance deficiencies and to correct them with adequate compensatory measures.

This evaluation could lead to potential changes to the ISA assumptions regarding the treatment of a particular NPH event. Reviewers should evaluate the following:

1. SSCs are designed and constructed to perform the safety function needed to meet the performance requirements with sufficient design basis documentation.

2. The ISA evaluation identifies those SSCs that are designated as IROFS.

3. The likelihood information (e.g., hazard curves) or consequence attributed to/related to an NPH needs to be accurate and clearly defined.

4. Configuration management is established to evaluate additions, modifications, or deterioration that may lead to significant physical change in SSCs that can affect the intended safety function.

5. Occurrence of an NPH, especially an earthquake, may affect multiple SSCs in a facility. This could lead to multiple concurrent failures.

6. The likelihood of failure and potential consequences are valid for the type of event.

Additional Considerations for Existing Processes At Existing Facilities

The following supplements the guidance in "Considerations for Existing Processes at Existing Facilities" from Appendix D of NUREG-1520. Many existing fuel cycle facilities were designed and constructed using applicable building codes and standards adopted by State or local authorities at the time the facility was constructed. These building codes and standards established minimum requirements for providing safety to life and property from seismic hazards. This goal of providing safety of life and property is accomplished through the specification of prescriptive criteria to achieve adequate performance of a structure to ensure its capability to withstand a defined intensity of earthquake ground motions. The development of seismic design criteria is an ongoing process of improvement which is reflected in the evolution of seismic criteria in building codes and standards. For example, a facility may have been designed and constructed with building codes and standards that contained criteria for seismic loads resulting from earthquakes having accelerations associated to 10 percent probability of exceedance in 50 years. If adequate documentation exists, such as design calculations or reference material, these facilities may be able to demonstrate that their SSCs will adequately perform with a low likelihood of structural collapse under the specified accelerations.

On the other hand, some fuel cycle facilities were designed and built to a building code that did not prescribe criteria for seismic hazards. For example, most facilities built in the eastern United States were designed without consideration of potential earthquake hazards. Given that these licensees still must consider seismic hazards as part of their ISA, the licensee may be able to make an assessment using the as-built condition of the facility. This assessment includes a review of existing documentation such as drawings and construction specifications to identify as-built characteristics of the SSCs. The assessment can identify information such as properties of materials used in construction, structural systems used, and elements that can affect seismic performance. Walk-downs of the facility can identify and confirm as-built data gathered as well as identify deviations from original drawings. From walk-downs, the licensee can identify and provide special emphasis on components that can affect operations with

hazardous materials. The NRC reviewer should assure that the assessment demonstrates that the performance requirements have been met.

Performance-Based Evaluation of Seismic Events

Licensees may demonstrate how portions of their facility meet the performance requirements of 10 CFR 70.61 by using analytical seismic evaluation methods to demonstrate the performance of the SSCs in the facility and how structural failures of those SSCs may lead to consequences of concern from seismic events. Performance-based design is an engineering approach, where the design process is structured to achieve performance requirements (structural limit states) specified by owners or licensees to meet a risk level to ensure adequate protection of public health and safety. Demonstration of performance can be done by selecting "performance objectives" that combine a desired performance level with a specified earthquake hazard. The concept of performance objectives is used widely in building codes and standards, such as the International Building Code, and standards for nuclear facilities, such as American Nuclear Society (ANS) 2.26, "Categorization of Nuclear Facility Structures, Systems, and Components for Seismic Design." The performance objectives can be established by licensees and applicants to take into consideration the radiological and chemical consequences of failures of SSCs. If these radiological and chemical consequences align with the performance requirements in 10 CFR 70.61, the NRC reviewer can validate compliance. The goal of seismic design calculations from building codes and standards is to provide a low risk of earthquake-related death or life threating injuries from a collapse of structures. When evaluating performance-based structural analyses for NPH, the reviewer should also consider how the licensee addresses the following:

- Concurrent failures;
- Proper assignment of an SSC performance goal with adequate construction methods based on accepted standards that provide acceptably low risk;
- Defined seismic design categories and limit states that are adequately supported by analyses (graded approach);
- Documented qualitative or quantitative values of the critical design parameters at which the SSC fails to perform its safety function;
- Consideration of functions such as emergency response, control rooms, etc.; and
- Limited deformations of design equipment and subsystems in order to maintain safety function.

Graded Approach to Consideration of NPH

The use of a graded approach to demonstrate compliance with applicable regulatory requirements is outlined in Appendix B of Chapter 3 of NUREG-1520 as it relates to the ISA. A graded approach recognizes the diversity of regulated facilities and processes, potential hazards, and safety functions needed to prevent accident sequences and/or mitigate the consequences of events from NPH. A graded approach can be used by applicants and licensees to place SSCs into different categories such that the required level of analysis, the

complexity of the design or evaluation approach, documentation, and actions are commensurate with:

- The relative importance to safety of the structure or component or the amount of risk reduction attributed to the structure or component to meet the performance requirements;

- The particular characteristics of the structure or component, and the complexity and potential consequences that could result in the event of failures; and

- The magnitude of the NPH.

The objective of building codes and standards for NPH protection is to design structures to a "life safety" performance level to prevent structural collapse or failures that could endanger lives or prevent safe egress of personnel. The reviewer should verify that the licensee's approach considers how failures of components can affect regulated material, affect mitigation measures, and produce releases that lead to consequences that exceed the performance requirements of 10 CFR Part 70. In reviewing the graded approach, the reviewer should consider how the licensee:

- Prevents loss of structural integrity that could lead to a release in excess of the performance requirements;

- Prevents loss of capability to perform functions important to safety during and/or after the natural phenomena event that could lead to consequences to the public and/or worker; and

- Confines hazardous material.

A prioritization or graded approach that considers risk may also serve as a decision tool to identify how deficiencies will be corrected. For example, aspects of the load bearing elements of the building structure that house hazardous material may be evaluated further using more complex methodologies. Using the prioritization approach, the licensee may establish a plan to retrofit or perform detailed analyses of critical SSCs first and then provide a plan with a schedule to evaluate SSCs relied on for a safety function of a lower risk reduction.

The reviewer should ensure that the licensee's "evaluation basis seismic hazard," to serve as the input to the seismic re-evaluation, provides for adequate protection to meet the performance requirements in 10 CFR 70. The reviewer should consider if the evaluation basis event adequately characterizes conditions at the site such as soil properties and local seismicity. If the licensee's evaluation of an SSC identifies a deficiency in that it does not meet the criteria under the selected hazard, the reviewer should evaluate the retrofit plan which may include several options considered by the licensee to address the deficiency. Such options may include

- Conduct a more rigorous evaluation of the deficiencies to account for potential conservatism not accounted for in the simplified evaluation;

- Retrofit the SSC to improve resistance to the selected hazard;

- Modify usage of the SSC to eliminate the hazards; and

- Incorporate a combination of mitigation/prevention strategies to reduce the materials at risk (seismic isolation valves, bunkers, etc.).

Other Considerations

The regulatory requirements in 10 CFR 70.62(c)(1) require licensees to conduct and maintain an ISA. Consistent with the regulations and guidance in NUREG-1520, licensees should establish a process to periodically re-evaluate changes to the natural phenomena data and data collection methods, modeling techniques (hazard curves), and assessment methods to ensure assumptions are still valid. If the assumptions used for determining credibility of NPH events change, such as updated building codes and standards, the staff should assess the licensee's documentation of the processes used to evaluate any impacts to the current safety basis that could be affected by these changes.

The effects from failures and impacts to the facility from natural phenomena events should be considered in radiological safety, chemical safety, nuclear criticality safety and fire safety assessments. Particular attention should be given to the potential for natural phenomena events to cause multiple failures. Licensee emergency response functions should consider the necessary actions to prevent or mitigate the potential consequences of a natural phenomena event (i.e., criticality, disabled water supply, loss of electrical power, delayed off-site response). For example, licensees can establish procedures for assessing damage to facilities after severe natural phenomena events as well as emergency response procedures for re-entry to the facilities considering the effects of potential failure to alarms and instrumentation.

The operation of fuel cycle facilities inherently involves multiple significant hazards, such as: large inventories of UF_6, uranium dioxide (UO_2) and triuranium octoxide (U_3O_8) powder, fissile material that can go critical, process and byproduct chemicals such as hydrogen fluoride (HF) and nitric acid (HNO_3), and similar process hazards. Because NPH events can affect large areas of a facility, emergency response functions should consider how they would respond to events with multiple consequences and activities at the same time, which would normally require different responses.

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