8.0 CHEMICAL SAFETY

8.1 PURPOSE OF REVIEW

The purpose of this review is to establish reasonable assurance that the applicant has designed a facility that provides for adequate protection against chemical hazards related to the storage, handling, and processing of licensed material as required by the proposed 10 CFR Part 70. This review also establishes that the applicant's facility and system design and facility layout pertaining to chemical safety is based upon defense-in-depth practices and, where practicable, favors passive control systems over active ones.

Safety issues are initially evaluated as part of the applicant's Integrated Safety Analysis (ISA); the ISA Summary identifies potential accidents at the facility (SRP Chapter 5.0). Chemical safety addresses the consequences of potential accidents involving licensed materials from hazardous chemicals and accidents due to chemicals that create potentially hazardous situations (e.g., an inert gas incapacitating or suffocating operators or precluding entry to an area of the facility handling licensed materials), and the controls used to prevent the occurrence or mitigate the consequences of accidents. The review should determine that the applicant's facility design and items relied on for safety provide reasonable assurance of chemical safety at the facility for routine operations, off-normal conditions, and potential accidents.

8.2 RESPONSIBILITY FOR REVIEW

Primary: Chemical Process Specialist

Secondary: Project Manager

Supporting: Project Manager as the primary reviewer of Organization and Administration, ISA Reviewer, Health Physicist Reviewer, Environmental Protection Reviewer, Primary Reviewers of Applicable Sections of SRP Chapter 15.0, and Inspection Staff (as needed)

8.3 AREAS OF REVIEW

The proposed 10 CFR Part 70 requires applicants to establish a safety program to demonstrate compliance with the performance requirements. This does not necessarily require that the applicant establish a separate chemical safety program, but does require that chemical hazards and accident sequences that affect radiological materials be considered and adequately prevented or mitigated.

At NRC-licensed facilities, as stated in U.S. Nuclear Regulatory Commission, *Memorandum of Understanding between the Nuclear Regulatory Commission and the Occupational Safety and Health Administration: Worker Protection at NRC-Licensed Facilities,* Federal Register 53 (No. 210), 43950-43951, October 31,1998, the NRC oversees chemical safety issues related to (i) radiation risk produced by radioactive materials; (ii) chemical risk produced by radioactive

materials; and (iii) plant conditions which affect the safety of radioactive materials and thus present an increased radiation risk to workers. The NRC does not oversee facility conditions which result in an occupational risk but do not affect the safe use of licensed radioactive materials.

The following areas should be reviewed:

A. Chemical Process Description - including process chemistry, process flow diagrams, mass/energy balances, inventories, major/significant process steps, safe operating limits for key parameters (e.g., temperature and pressure), and major pieces of equipment.

B. List of Hazardous Chemicals Affecting Licensed Materials - including potential interactions between chemicals and other materials as described in the ISA Summary.

C. Chemical Accident Sequences - including unmitigated analyses involving the hazardous chemicals and licensed materials, as described in the ISA Summary.

D. Chemical Accident Consequences - including assumptions, bases, and methods used to estimate the consequences of accidents for the workers, co-located workers, and the public identified in the ISA that involve hazardous chemicals and licensed materials.

E. Chemical Safety Controls - including the quantity and quality of controls used to mitigate or protect against accidents involving the release of hazardous chemicals and/or licensed materials, as determined by the ISA.

F. Chemical Process Safety Interfaces - including a description of how chemical safety interfaces with and is affected by other areas of review, including quality assurance, training, configuration management, maintenance, etc. Because the results of the ISA form the basis for much of the chemical safety of the design and facility, the primary reviewer should also review the ISA (see SRP Chapter 5.0). Supporting reviewers should confirm that provisions made in the application for chemical safety are in accordance and consistent with specified sections of the SRP. For example, the health physicist that is a primary reviewer from SRP Chapter 9.0, “Radiation Safety," as a supporting reviewer for chemical safety, should establish that the chemical safety program will not have unacceptably adverse impacts on the radiological safety at the facility.

Information contained in the application should be of sufficient quality and detail to allow for an independent review, assessment, and verification by the reviewers. Some of the information may be referenced to other sections of the application, or incorporated by reference, provided that these references are clear, specific, and essentially complete. Trade secrets or proprietary information will be treated in accordance with 10 CFR 2.790.

8.4 ACCEPTANCE CRITERIA

8.4.1 Regulatory Requirements

Requirements for protection against the occurrence of adverse chemical process consequences that could result from the handling, storage, or processing of licensed material and hazardous chemicals are found in the proposed 10 CFR Part 70. The following sections are particularly relevant to chemical safety: safety performance requirements (proposed §70.61), safety program and ISA (proposed §70.62), and the baseline design criteria for new facilities or new processes at existing facilities (proposed §70.64, specifically §70.64(a)(5) chemical protection and §70.64(b) defense-in-depth practices), and where applicable, passive systems and features.

8.4.2 Regulatory Guidance

Listed in this section are the applicable portions of the NRC Inspection Manual and NUREGs that provide a basis that is generally acceptable to the NRC staff for satisfying the regulatory requirements listed in Section 8.4.1.

A. Nuclear Regulatory Commission (U.S.) (NRC). NRC Inspection Manual, Chapter 2603, "Inspection of the Nuclear Process Safety Program at Fuel Cycle Facilities." NRC: Washington, D.C.

B. U.S. NRC. NUREG/CR-6410, "Nuclear Fuel Cycle Accident Analysis Handbook." NRC: Washington, D.C. 1998.

C. U.S. NRC. NUREG-1513, "Integrated Safety Analysis Document." NRC: Washington, D.C.

D. U.S. NRC. NUREG-1601, "Chemical Process Safety at Fuel Cycle Facilities." NRC: Washington, D.C. 1997.

8.4.3 Regulatory Acceptance Criteria

The NRC reviewers should find the applicant's chemical process safety information acceptable if there is reasonable assurance that the regulatory acceptance criteria are adequately addressed and satisfied. The applicant may elect to incorporate some or all of the requested chemical process information in the Facility and Process Overview (SRP Section 1.1) and the ISA Summary (SRP Chapter 5.0) rather than in this section. Either approach is acceptable as long as the information is adequately cross-referenced.

8.4.3.1 Chemical Process Description

The chemical process description should be acceptable if it addresses the baseline design criteria for chemical safety and contains the following information:

A. Chemical Process Summary: In the chemical process summary, the applicant includes the purpose or objective of the major chemical process steps (e.g., valence adjustment and oxidation) including the operations to be performed, overall mass, energy, radioactivity (Bq or curie), and waste balances (including emission, effluents, the disposition of wastes and chemical/radionuclide concentrations).

B. Chemical Process Details: In the chemical process description, the applicant identifies the names and formulae of chemical reactants and products (input and output) to process steps, rates of reactions, and the operating conditions (e.g., temperature, pressure, flow rate, and pH), and identifies which chemicals contact licensed materials or could significantly impact operations with licensed materials. The chemical process description includes sufficient information (e.g., mass/energy/radioactivity balances, process flow diagrams, and descriptive equations) to enable the reviewers to understand the hazards associated with the chemical processes.

C. Process Chemistry: The description of the process chemistry provides stoichiometric equations for the primary/side reactions and degradation phenomena of the chemical moieties. Generation of flammable gases (e.g., hydrogen from reactions unique to MOX processes such as the degradation of organic solvents in the presence of higher alpha radiation from plutonium and americium) should be included. The process chemistry discussion addresses initial startup conditions, normal operations, shutdown, and process testing and qualification.

D. Chemical Process Equipment, Piping, and Instrumentation: The description of the chemical process equipment, piping and instrumentation includes descriptions, diagrams, layouts, schematics, and process logic for the major equipment, piping, and controls that may be important to chemical process safety. The applicant identifies the codes and standards used to construct the process equipment (e.g., American Society of Mechanical Engineers (ASME) B.31.3 Process Piping Code). In addition, the applicant describes specific areas of hazards, such as large inventories in vessels or columns. The applicant also includes the results of its evaluation of the potential deleterious effects of processes (e.g., pH, radiation, and upset conditions) on equipment.

E. Chemical Process Inventories: The chemical inventory information provides the complete chemical and radionuclide inventories within the facility for routine and credible off-normal conditions.

F. Chemical Process Ranges: The description of the range of chemicals includes the approximate input, in-process, and output ranges of chemical and radioisotope concentrations, mass flow rates, and other properties (e.g., significant enthalpy changes during an acid/base reaction).

G. Chemical Process Limits: The identification and description of chemical process limits identify and discuss the limits in terms of parameters important to safety (such as chemical concentrations, temperature, pressure) and address the consequences of exceeding these limits. The process description identifies those limits that conservatively bound potential off-normal and accident conditions and would be suitable for subsequent consequence analyses.

8.4.3.2 List of Hazardous Chemicals and Potential Interactions

The list of hazardous chemicals and potential interactions should be acceptable if they contain the following information:

A. Chemicals: The list of hazardous chemicals includes the major chemicals used in the process. The list includes chemical form, concentration, maximum projected inventory and location, associated exposure limits (e.g., Occupational Safety and Health Administration (OSHA) Permissible Exposure Limit, Emergency Response Planning Guidelines, etc.), and safety precautions.

B. Chemical Interactions: The list of chemical interactions includes potential reactions and interactions between materials stored and used at the facility that have the potential to affect the safe handling of licensed radioactive materials, as determined by the ISA. The list includes a chemical interaction matrix (see NUREG-1513), or equivalent, for determining chemical incompatibilities and potentially unsafe interactions. The matrix summarizes the effects of intense radiolysis as potential initiators of chemical reactions and interactions. The list uses standard groupings of chemicals (e.g., acids, bases, oxidizers, organics) and includes potential chemical/radiolytic interactions between chemicals and items not generally considered as reagents such as ion exchange resins, sorbents, lead-lined gloves, glovebox covers, and sealing materials (e.g., mechanical pump seals and gaskets). The list includes potential deleterious effects of the degradation products of solvent/organic compounds (e.g., di-butyl phosphate generated by the degradation of tri-butyl phosphate) on licensed material. Additionally, the list includes possible adverse impacts to the pyrophoric licensed material resulting from the loss of the inert atmosphere, as appropriate.

C. Unusual and Unexpected: The list of hazardous chemicals and potential interactions addresses unusual and unexpected chemical interactions from the different facility conditions that may affect the safety of licensed materials, including those that impact controllability and habitability issues such as emission of inert gas, CO_2 or NOx. The applicant has addressed the potential accumulation of flammable/combustible gases in tank ullage spaces and vent lines, as appropriate.

8.4.3.3 Chemical Accident Sequences

The chemical accident sequences are acceptable if they contain the following information:

A. Chemical Accident Sequence Bases: The bases and references used in the chemical accident sequences are supported by applicable data and references. The applicant includes estimated annual frequencies and probabilities over the facilities operational period. The accident sequences include the chemical hazard evaluation that identifies the potential interactions between process chemicals, licensed materials, process conditions, facility personnel/operators, and structures, systems, and components.

B. Unmitigated Sequences: The applicant clearly delineates these chemical accident sequences as unmitigated for the purposes of analysis and item categorization.

C. Estimated Concentrations: The estimates of hazardous chemical concentrations include techniques, assumptions, and models that are consistent with industry practice, are verified and/or validated, and follow the guidance on atmospheric and consequence modeling found in NUREG/CR-6410, *Nuclear Fuel Cycle Accident Analysis Handbook*, 1998. The applicant provides evidence that the techniques, assumptions, and models used are appropriate for the application and that they lead to a conservative estimate of potential consequences.

D. Concentration Limits: The chemical concentration limits have a supporting rationale or basis such as Acute Exposure Guideline Level (AEGL) or Emergency Response Planning Guide (ERPG) values or other cited values, such as those values developed by OSHA or NIOSH (National Institute for Occupational Safety and Health). If the applicant does not use a published standard, or if a chemical has an unknown exposure standard, the applicant may propose an alternate standard accompanied by supporting documentation to justify the selection of such an alternative. The performance requirements of proposed 10 CFR 70.61 are based upon acute chemical exposures, and, as such, chemical concentration values such as OSHA permissible exposure limits or other time weighted average values should not be used unless a rational basis is provided in the ISA.

8.4.3.4 Chemical Accident Consequences

The primary reviewer should coordinate the chemical accident consequence reviews with the primary reviewers of the ISA Summary (SRP Chapter 5.0) and Environmental Protection (SRP Chapter 10.0) chapters and meet the requirements for proposed 10 CFR 70.61 and 70.62. The chemical accident consequences should be acceptable if they contain the following information:

A. Analysis: The accident consequence analysis is encompassed by the ISA, which identifies potential accident sequences with hazardous chemicals and licensed materials, and the consequences are estimated for both workers and members of the public. Dispersion models may be necessary for estimating the concentration and potential impacts of such chemicals at various distances from the point of release. In this case, the applicant provides information to support the conclusion that the models used are appropriate for the application and physical phenomena occurring, that the models have been validated and verified, and that the assumed data input leads to a conservative estimate of potential consequences. Consequence analysis follows the guidance found in NUREG/CR-6410, *Nuclear Fuel Cycle Facility Accident Analysis Handbook*.

B. Latent Impacts: The applicant's accident consequence analysis considers if there are any residual, long-term impacts to worker and public health that could result from an acute chemical exposure to licensed material or hazardous chemicals produced from licensed material (i.e., as compared to the analysis in Item A, which focus primarily on the prompt effects).

C. Uncertainty: The accident consequence analysis includes consideration of uncertainty and errors in comparing chemical hazards and radioactive material effects with the performance requirements of proposed 10 CFR 70.61.

8.4.3.5 Process Safety Information

Process safety information should be acceptable if it contains the following information:

A. The applicant's identification of chemical process safety controls used to prevent or mitigate potential accidents are supported by appropriate safety analyses, and the applicant provides reasonable assurance that these safety controls will be available and reliable upon demand.

B. The application identifies the design basis that provides safety for normal operations. A description could include specified features such as materials of construction, sizing, system fabrication, and process control schemes.

C. The process safety control discussion includes a description of the process and engineering design features used to control each process step, including set point ranges and any special administrative or procedural controls. The discussion describes the process safety features that are relied upon for chemical process safety, including the number and quality of controls used to protect against (reducing frequency and probability of occurrence) or mitigate (reducing consequences) accidents involving the release of hazardous chemicals as determined by the ISA.

D. Items relied on for safety are identified for those accident sequences that contain a chemical/process failure that may lead to radiological consequences that exceed the performance requirements of the proposed 10 CFR 70.61.

E. The applicant uses a graded approach to safety in accordance with proposed 10 CFR 70.62(a). The applicant ensures that the grading of items relied on for safety is appropriate and sufficient to protect against chemical/process risk, including a consideration of relying upon passive over active systems, defense-in-depth, and fail safe features. For common mode failures, the applicant considers design features in the application that utilize independent sources of motive force and power for such items as actuators, pumps, and eductors.

F. The application describes the management measures that assure the availability and reliability of items relied on for safety for chemical and process safety. Management measures may be graded commensurate with risk.

8.4.3.6 Chemical Process Safety Interfaces

The description of chemical process safety interfaces should be acceptable if the application addresses how the following areas of review interface with aspects of chemical safety at the facility (see the appropriate SRP sections and chapters as specified in parentheses):

A. Organizational Structure (SRP Chapter 4.0);
B. Human Factors (SRP Chapter 12.0);
C. Emergency Management (SRP Chapter 14.0);
D. Quality Assurance (SRP Section 15.1)
E. Configuration Management (SRP Section 15.2);
F. Maintenance (SRP Section 15.3);
G. Training and Qualification (SRP Section 15.4);
H. Procedures (SRP Section 15.5);
I. Audits and Assessments (SRP Section 15.6);
J. Incident Investigations (SRP Section 15.7);
K. Records Management (SRP Section 15.8);

8.5 REVIEW PROCEDURES

8.5.1 Acceptance Review

The primary reviewer should perform an acceptance review to determine if the application (construction or license) adequately addresses the items in Section 8.3, "Areas of Review."

Guidance specific to the application for construction approval and the license application is provided below.

A. Application for Construction Approval

   Specifically, the safety assessment of the design basis should address Section 8.3(A)-(E) consistent with the level of design. Where information is under development or not yet available, the applicant may use a commitment to provide the material with the license application in lieu of the actual material.

B. License Application for Operations

   Specifically, the safety assessment includes as part of the license application should address Section 8.3(A)-(F) in full.

If the primary reviewer verifies that chemical safety is adequately addressed (construction or license), the primary reviewer should accept the application for the safety evaluation in Section 8.5.2. If the primary reviewer identifies significant deficiencies in the material provided, the primary reviewer should request that the applicant submit additional information prior to the start of the safety evaluation.

8.5.2 Safety Evaluation

After determining that the application is acceptable for review in accordance with either Section 8.5.1.A (construction) or 8.5.1.B (license), the primary reviewer should perform a safety evaluation against the acceptance criteria described in Section 8.4. On the basis of its review, the staff may request that the applicant provide additional information or modify the application to meet the acceptance criteria in SRP Section 8.4.

Guidance specific to the application for construction approval and the license application is provided below.

A. Application for Construction Approval

   The primary reviewer should establish that the applicant's facility design as described in the safety assessment of the design basis and other commitments, as they relate to chemical safety, meet or exceed the regulatory acceptance criteria in Section 8.4.

B. License Application for Operations

   The primary reviewer should establish that the applicant's facility design, operations, and chemical safety items provide reasonable assurance that they will function as intended and provide for the safe handling of licensed materials at the facility.

When the safety evaluation is complete (either construction or operations), the primary reviewer, with assistance from the other reviewers, should prepare the chemical safety input for the Safety Evaluation Report (SER), as described in Section 8.6 using the acceptance criteria from Section 8.4. The secondary reviewer should coordinate the chemical safety input with the balance of the reviews and the SER.

8.6 EVALUATION FINDINGS

The primary reviewer should document the safety evaluation by preparing material suitable for inclusion in the SER. The primary reviewer should describe the review, explain the basis for the findings, and state the conclusions.

The staff could document the safety evaluation for the application for construction approval as follows:

> *The staff reviewed the application for construction approval for [insert name of facility] according to Chapter 8.0 of NUREG-1718. The staff evaluated [Insert a summary statement of what was evaluated] and found that [summarize the findings]. Based on the review of the application for construction approval, the NRC staff concluded that the applicant adequately described and assessed accident consequences having potentially significant chemical consequences and effects that could result from the handling, storage, or processing of licensed materials. The applicant's design basis and safety assessment of the design basis identified and evaluated those chemical process hazards and potential accidents. The staff reviewed these safety controls and finds them acceptable.*
>
> *The staff concluded that the applicant's design basis for managing chemical process safety and the chemical process safety controls meet the requirements in the area of chemical safety to approve construction of the facility under proposed 10 CFR Part 70.*

The staff could document the safety evaluation for the license application as follows:

> *The staff reviewed the license application for [insert facility name] according to Chapter 8 of NUREG-1718. The staff evaluated [Insert a summary statement of what was evaluated] and found [insert a description of the findings]. Based on the review of the license application, the staff concluded that the applicant adequately described and assessed accident consequences having potentially significant chemical consequences and effects that could result from the handling, storage, or processing of licensed materials. The ISA Summary identified those chemical process hazards and potential accidents, and established safety controls to ensure safe facility operation. To ensure that the performance requirements in proposed 10 CFR Part 70, are met, the applicant will ensure that controls are maintained available and reliable. The staff reviewed these safety controls and the applicant's plan for managing chemical process safety and its potential effects upon licensed radioactive materials and finds them acceptable.*
>
> *The staff concludes that the applicant's plan for managing chemical process safety and the chemical process safety controls meet the requirements to possess and use SNM according to the proposed 10 CFR Part 70.*

8.7 REFERENCES

A. Chemical Manufacturers Association, *Responsible Care®, Process Safety Code of Management Practices*. Washington, D.C. 1990.

B. American Institute of Chemical Engineers (AIChE). Center for Chemical Process Safety, *Guidelines for the Technical Management of Chemical Process Safety*. AIChE: New York, 1989, Chapter 11, as revised.

C. Code of Federal Regulations, Title 10, Part 70, Domestic Licensing of Special Nuclear Material, U.S. Government Printing Office, Washington, D.C., 1999.

D. Proposed 10 CFR Part 70, "Domestic Licensing of Special Nuclear Material; Possession of a Critical Mass of Special Nuclear Material." 64 FRN 41338, July 30, 1999.

E. Code of Federal Regulations, *Title 29 Labor*, Part 1900, §1910.119, "Process Safety Management of Highly Hazardous Chemicals."

F. U.S. NRC. NRC Inspection Manual, Chapter 2603, "Inspection of the Nuclear Process Safety Program at Fuel Cycle Facilities." NRC: Washington, D.C.

G. U.S. Nuclear Regulatory Commission, *Memorandum of Understanding between the Nuclear Regulatory Commission and the Occupational Safety and Health Administration: Worker Protection at NRC-Licensed Facilities,* Federal Register 53 (No. 210), 43950-43951, October 31, 1988.

H. U.S. NRC. NUREG/CR-6410, "Nuclear Fuel Cycle Accident Analysis Handbook." NRC: Washington, D.C. 1998.

I. U.S. NRC. NUREG-1601, "Chemical Process Safety at Fuel Cycle Facilities." NRC: Washington, D.C. 1997.