

CHEMICAL SAFETY

6.1 PURPOSE OF REVIEW

The purpose of this review is to establish that there is 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 radioactive material as required by the Baseline Design Criterion for Chemical Protection, in 10 CFR 70.64 as revised¹.

Safety issues are initially evaluated as part of the applicant's Integrated Safety Analysis (ISA), which identifies potential accidents at the facility (SRP Chapter 3). Chemical safety addresses the consequences of potential accidents due to hazardous chemicals and accidents due to chemicals that create potentially hazardous situations (e.g., an inerting gas incapacitating or suffocating operators or precluding entry to an area of the facility handling licensed radioactive materials), and the controls used to prevent their occurrence or mitigate their consequences. The review should determine that the applicant's facility design and items relied upon for safety provide reasonable assurance of chemical safety at the facility for routine operations, off-normal conditions, and potential accidents.

6.2 RESPONSIBILITY FOR REVIEW

Primary: Chemical Process Specialist

Secondary: Licensing Project Manager

Supporting: Primary Reviewers of SRP Section 1.1, and Chapters 2.0, 3.0, 4.0 and 8.0. Primary Reviewers of Applicable Sections of SRP Chapter 11.0.

6.3 AREAS OF REVIEW

The regulations, 10 CFR 70.61 and 70.62, as revised, require applicants to establish minimum requirements for all items relied on for safety in their process design and description and a safety program. This does not necessarily require the establishment of 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 the NRC oversees chemical safety issues related to (i) radiation risk produced by radioactive materials; (ii) chemical risk produced by radioactive material; and (iii) plant conditions which affect or may affect the safety of radioactive materials and thus present an increased radiation risk to workers, the public, and the environment. The NRC does NOT

¹Nuclear Regulatory Commission (U.S.), Washington, D.C. "Domestic Licensing of Special Nuclear Material (10 CFR Part 70); Possession of a Critical Mass of Special Nuclear Material." *Federal Register*: Vol. 64, No. 146. pp. 41338-41357. July 30, 1999.

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have regulatory responsibility for plant conditions which may result in an occupational risk, but do not affect the safe use of radioactive materials.

The following areas should be reviewed:

1. Chemical Process Description - including process chemistry, flow diagrams, mass/energy balances, inventories, major/significant process steps, and major/significant pieces of equipment.
2. List of Hazardous Chemicals - including potential interactions between chemicals and other materials as determined by the ISA.
3. Chemical Accident Sequences - including unmitigated analyses involving the hazardous chemicals and licensed radioactive materials, as determined by the ISA.
4. Chemical Accident Consequences - including assumptions, bases, and methods used to estimate the consequences of accidents for the worker and the public identified in the ISA Summary that involve hazardous chemicals and licensed radioactive materials.
5. Chemical Safety Controls - including the number and quality of controls used to protect against (reduce frequency and probability of occurrence) or mitigate (reduce consequences) process and chemical accidents involving the release of hazardous chemicals and/or licensed radioactive materials, as determined by the ISA.
6. 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.

This information 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 incorporate by reference, provided that these references are clear, specific, and essentially complete.

6.4 ACCEPTANCE CRITERIA

6.4.1 Regulatory Requirements

The requirements for chemical safety are provided in the following:

Nuclear Regulatory Commission (U.S.), Washington, D.C. "Domestic Licensing of Special Nuclear Material (10 CFR Part 70)." *Federal Register*: Vol. 64, No. 146. pp. 41338--41357. July 30, 1999.

Specific citations are as follows:

1. § 70.64(a) has a Baseline Design Criterion for “chemical safety” and requirements regarding defense-in-depth practices.
2. § 70.61 contains performance requirements for the facility.

6.4.2 Regulatory Guidance

Listed in this section are the applicable portions of the NRC Inspection Manual and NUREG reports that, in general, provide guidance on satisfying the regulatory requirements cited in SRP Section 6.4.1.

1. Nuclear Regulatory Commission (U.S.) (NRC). Inspection Manual, Chapter-2603, “Inspection of the Nuclear Process Safety Program at Fuel Cycle Facilities,” NRC: Washington, D.C. latest revision.
2. ----- NUREG/CR-6410, “Nuclear Fuel Cycle Accident Analysis Handbook,” NRC: Washington, D.C. March 1998.
3. ----- NUREG-1513, “Integrated Safety Analysis Document,” NRC: Washington, D.C. latest revision.
4. ----- NUREG-1601, “Chemical Process Safety at Fuel Cycle Facilities,” NRC: Washington, D.C. 1997.

6.4.3 Regulatory Acceptance Criteria

The NRC reviewers should find the applicant’s chemical process safety information acceptable if it provides reasonable assurance that the regulatory review criteria (listed below) are adequately addressed and satisfied. The applicant may elect to incorporate some or all of the requested chemical process information in the ISA (see SRP 3.0) rather than in this section. Either approach is acceptable as long as the information is adequately cross-referenced.

6.4.3.1 Chemical Process Description

The chemical process description should be acceptable if it addresses the Baseline Design Criterion for chemical safety (10 CFR 70.64) and contains the following information:

1. Chemical Process Summary: The chemical process summary should be acceptable if it includes the purpose or objective of the major chemical process steps, including the operations to be performed, and overall mass, energy, radioactivity (curie), and waste balances.
2. Chemical Process Details: The details contained in the chemical process description should be acceptable if they identify chemical reactants and products (input and output) to process steps, rates of reactions, the operating conditions (e.g., temperature, pressure, flow rate, pH), and flow sheets, and identify which chemicals contact radioactive materials or could significantly impact operations with radioactive materials. The process description

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should include information sufficient to enable the reviewers to understand the hazards associated with the chemical processes.

3. Process Chemistry: The description of the process chemistry should be acceptable if it provides equations for the chemical reactions and degradation phenomena (including radiolysis) of the chemical species. The process chemistry discussion should address initial startup conditions, normal operation, shutdown, and process testing and qualification.
4. Chemical Process Equipment, Piping, and Instrumentation: The description of the equipment, piping and instrumentation used in chemical processing should be acceptable if it includes descriptions, diagrams, layouts, schematics, and process logic for the major equipment, piping, and controls that may be important to chemical process safety. Specific areas of potential hazards, such as large inventories in vessels or columns, should be mentioned and described. The potential, deleterious effects of the process (e.g., pH, radiation, upset conditions) upon equipment, piping, and instrumentation should be considered and, as appropriate, evaluated in the application.
5. Chemical Process Inventories: The chemical inventory information should be acceptable if it provides the complete chemical and radionuclide inventories within the facility for routine and credible off-normal conditions.
6. Chemical Process Ranges: The description of the range of chemicals should be acceptable if it includes the approximate input, in-process, and output ranges of chemical and radioisotope concentrations, and other properties (e.g., significant enthalpies).
7. Chemical Process Limits: The identification and description of chemical process limits should be acceptable if it identifies and discusses the limits in terms of parameters important to safety, such as chemical concentrations, temperature, pressure, etc., and addresses the consequences of exceeding or operating beyond these limits. The process description should identify those limits that reasonably and conservatively bound potential off-normal and accident conditions and that would be suitable for subsequent consequence analyses.

6.4.3.2 List of Hazardous Chemicals and Potential Interactions

The list of hazardous chemicals and potential interactions should be acceptable if it addresses 10 CFR 70.62 and § 70.64, and the following:

1. Chemicals: The list of hazardous chemicals is acceptable if it includes all of the chemicals introduced into the process and includes the chemical form, physical state(s), locations, and radionuclide content, as appropriate.
2. Chemical Interactions: The list of potential interactions should be acceptable if it considers potential chemical reactions and interactions between materials stored and used at the facility that have the potential to affect the safe handling of radioactive materials, as determined by the ISA. Items not usually considered as chemicals (e.g., resins and

gaskets) should be included if they have the potential to affect process safety and radioactive materials.

3. Unusual and Unexpected: The list of hazardous chemicals and potential interactions should be acceptable if it addresses unusual and unexpected chemical interactions from the different plant conditions (e.g., high levels of radiation) that may affect the safety of radioactive materials, including those that impact controllability and habitability issues, including but not limited to conditions such as inerting, nitrogen oxides, and flammable gas accumulation.

6.4.3.3 Chemical Accident Sequences

The chemical accident sequences should be acceptable if they address 10 CFR 70.61 and 70.62, and the following:

1. Chemical Accident Sequence Bases: The bases and references used in the chemical accident sequences should be acceptable if supported by applicable data and references, and if the applicant includes estimated annual frequencies and probabilities over the plant's operational period. The accident sequences should include the chemical hazard evaluation that identifies the potential interactions between process chemical, radioactive materials, process conditions, plant personnel/operators, and structures, systems, and components.
2. Unmitigated Sequences: The unmitigated chemical accident sequences should be clearly delineated as unmitigated for the purposes of analysis and item categorization for safety.
3. Estimated Concentrations: The estimates of hazardous chemical concentrations should be acceptable if the techniques, assumptions, and models used in the estimates are consistent with industry practice and 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."
4. Concentration Limits: The chemical concentration limits should be acceptable if they have a supporting rationale or basis such as AEGL (Acute Exposure Guideline Level) or ERPG (Emergency Response Planning Guide) values or other cited values (e.g., from OSHA, NIOSH). 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 §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.

6.4.3.4 Chemical Accident Consequences

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Chemical accident consequence reviews should be coordinated with the ISA (SRP Chapter 3.0) and Environmental (SRP 9.0) chapters and meet the requirements for 10 CFR 70.61 and 70.62.

1. **Analysis:** the accident consequence analysis should be acceptable if the ISA identifies potential accident sequences with hazardous chemicals and radioactive 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 should provide 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 analyses should follow the guidance found in NUREG/CR-6410, *Nuclear Fuel Cycle Facility Accident Analysis Handbook*.
2. **Latent Impacts:** the accident consequence analysis should be acceptable if the applicant considers if there are any residual, long-term impacts to worker and public health (i.e., as compared to the previous analyses, which focus primarily on the prompt effects from dispersion modeling via an inhalation pathway) from the chemical hazard effects upon radioactive materials.
3. **Uncertainty:** the accident consequence analysis should be acceptable if the analysis includes consideration of uncertainty and errors in comparing chemical hazards and radioactive material effects with the performance requirements of § 70.61.

6.4.3.5 Chemical Safety Controls

Chemical safety controls should be acceptable if the identification of the controls used to prevent or mitigate potential accidents is supported by appropriate safety analyses, and if the applicant provides reasonable assurance that these safety controls will be available and reliable upon demand. An adequate application should satisfy the criteria listed below.

1. 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.
2. The chemical 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 (reduce frequency and probability of occurrence) or mitigate (reduce consequences) accidents involving the release of hazardous chemicals as determined by the ISA.
3. Items relied upon 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.

4. If the applicant has elected to follow a graded approach to safety in accordance with 70.62(a), the review should establish that the grading of items relied upon 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 review should evaluate design features in the application that utilize independent sources of motive force and power for such items as actuators, pumps, and eductors.
5. The application describes the management measures that assure the availability and reliability of items relied upon for safety for chemical and process safety. Management measures may be graded commensurate with risk.

6.4.3.6 Chemical Process Safety Interface

The description of chemical process safety information 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):

1. Organizational Structure (SRP Section 2.1)
2. Emergency Management (SRP Chapter 8.0)
3. Configuration Management (CM - SRP Section 11.1)
4. Maintenance (SRP Section 11.2)
5. Quality Assurance (QA - SRP Section 11.3)
6. Training and Qualification (SRP Section 11.4)
7. Human Factors (SRP Section 11.5)
8. Audits and Assessments (SRP Section 11.6)
9. Incident Investigations (SRP Section 11.7)
10. Procedures (SRP Section 11.9)

6.5 REVIEW PROCEDURES

6.5.1 Acceptance Review

The primary reviewer evaluates the application to determine whether it addresses the "Areas of Review" discussed in Section 6.3, above. If significant deficiencies are identified, the applicant should be requested to submit additional material before the start of the safety evaluation.

6.5.2 Safety Evaluation

After determining that the application is acceptable for review in accordance with Section 6.5.1, above, the primary reviewer will perform a safety evaluation against the acceptance criteria described in Section 6.4. If during the course of the safety evaluation, the primary reviewer determines the need for additional information, the primary reviewer coordinates a request for additional information with the licensing project manager.

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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 3.0). Chemical safety, as defined in the SAR, should conform to the level of safety deemed necessary by the ISA. 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 radioactive materials at the facility. The primary reviewer should identify the mechanisms that will allow the applicant to identify and correct potential problems.

The secondary reviewer should confirm that the chemical safety approach is consistent with other sections of the application. Information provided for chemical safety should be of comparable quality and detail, and should not contradict or adversely impact information contained in other sections of the application.

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 primary reviewer from SRP Chapter 4.0, "Radiation Safety" (usually a health physicist), as a supporting reviewer for chemical safety, should establish that the program described by the applicant provides reasonable assurance for the facility, its operations, and the chemical safety program will not have unacceptably adverse impacts on the radiological safety at the facility.

For an existing facility, the NRC reviewers may wish to visit the site and facility personnel in order to gain a better understanding of the process, its potential hazards, and safety approaches. For a planned facility, the NRC reviewers may wish to meet with the design team in order to gain a better understanding of the process, its potential hazards, and safety approaches.

When the safety evaluation is complete, 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 6.6 using the acceptance criteria from Section 6.4. The secondary reviewer should coordinate the chemical safety input with the balance of the reviews and the SER.

6.6 EVALUATION FINDINGS

The primary reviewer writes an SER section addressing each topic reviewed under this SRP Chapter and explains why the NRC staff has reasonable assurance that the chemical safety part of the application is acceptable. License conditions may be proposed to impose requirements where the application is deficient. The SER should include a summary statement of what was evaluated and the basis for the reviewers' conclusions.

The staff can document the evaluation as follows:

The staff has evaluated [Insert a summary statement of what was evaluated and why the reviewer finds the submittal acceptable.] Based on the review of the license application, the NRC staff has concluded that the applicant has adequately described and

assessed accident consequences having potentially significant chemical consequences and effects that could result from the handling, storage, or processing of radioactive materials. A hazard analysis has been conducted that identified and evaluated those chemical process hazards and potential accidents, and established safety controls to ensure safe facility operation. To ensure that the performance requirements in 10 CFR 70.61, as revised, are met, the applicant will ensure that controls are maintained available and reliable. The staff has reviewed these safety controls and the applicant's plan for managing chemical process safety and its potential effects upon 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 of 10 CFR 70.61, 70.62, and 70.64, and provide reasonable assurance that the health and safety of the public, workers, and the environment will be protected.

6.7 REFERENCES

1. Chemical Manufacturers Association, (CMA). "Responsible Care[®], Process Safety Code of Management Practices." CMA: Washington, D.C. 1990.
2. Center for Chemical Process Safety, (CCPS). "Guidelines for the Technical Management of Chemical Process Safety." CCPS/American Institute of Chemical Engineers: New York, 1989, Chapter 11, as revised.
3. Nuclear Regulatory Commission (U.S.), Washington, D.C. "Domestic Licensing of Special Nuclear Material (10 CFR Part 70); Possession of a Critical Mass of Special Nuclear Material." *Federal Register*: Vol. 64, No. 146. pp. 41338-41357. July 30, 1999.
4. Code of Federal Regulations, *Title 29, Labor*, Part 1910.119, "Process Safety Management of Highly Hazardous Chemicals," as revised.
5. Nuclear Regulatory Commission, (U.S.) (NRC). NRC Inspection Manual, Chapter 2603, "Inspection of the Nuclear Chemical Process Safety Program at Fuel Cycle Facilities," NRC: Washington, D.C., as revised.
6. ----- Washington, D.C. , "Memorandum of Understanding between the Nuclear Regulatory Commission and the Occupational Safety and Health Administration: Worker Protection at NRC-Licensed Facilities, *Federal Register*: Vol. 53, No. 210. pp. 43950-43951. October 31, 1988.
7. ----- NUREG/CR-6410, "Nuclear Fuel Cycle Accident Analysis Handbook." NRC: Washington, D.C. 1998.
8. ----- NUREG-1601, "Chemical Process Safety at Fuel Cycle Facilities." NRC: Washington, D.C. 1997.